Health-promoting bioactive compounds in dried food products

Associate Professor Dr. Pramote KHUWIJITJARU

Department of Food Technology, Faculty of Engineering and Industrial Technology, Silpakorn University

About me

- B. Sc. (Food Technology), Silpakorn University
- M. Agric. Sci., Kyoto University, Japan
- D. Agric. Sci., Kyoto University, Japan

Fellowships

- 2022: JSPS Invitational Fellowship for Research (Kyoto University of Advanced Science, Japan)
- 2017: ASEA-UNINET Staff Exchange (University of Innsbruck, Austria)
- 2016: Visiting Associate Professor (Kyoto University, Japan)
- 2014: JSPS Invitation Fellowship (Kyoto University, Japan)
- 2013: JASSO Follow-up Research Fellowship (Kyoto University, Japan)
- 2011: JSPS Invitation Fellowship (Kyoto University, Japan)

Proximate compositions of foods

Cabbage

- Water 92.8%
- Protein 1.45%
- Fat 0.2%
- Ash (mineral) 0.7 %
- Carbohydrate 3.2%
- Fiber 1.6%

Papaya

- Water 89.4%
- Protein 0.6%
- Fat   0.1%
- Ash (mineral) 0.6%
- Carbohydrate 7.44%
- Fiber 1.9%

https://inmu2.mahidol.ac.th/thaifcd

Proximate compositions of foods

Anchovy

- Water 80.5%
- Protein 18%
- Fat 0.3%
- Ash (mineral) 1.1%
- Carbohydrate 0.1%

Beef

- Water 72.6%
- Protein 20.3%
- Fat 4.2%
- Ash (mineral) 3.1%

https://inmu2.mahidol.ac.th/thaifcd

Energy, moisture and macronutrient content of selected African leafy vegetables (values per 100 g edible portion, fresh weight basis).

Table 1

Energy, moisture and macronutrient content of selected African leafy vegetables (values per 100 g edible portion, fresh weight basis).

African leafy vegetables	Energy kJ (kcal)	Moisture (g)	Protein (g)	Fibre (g)	Fat (g)	Carbohydrates (g)
Adansonia digitata	289 (69)[a]	77[a]	4[a]	3§[a]	0.3[a]	16†[a]
Amaranthus sp.	113–222 (27–53)[b]	83–91[b]	4–6[b]	3§[b]	0.2–0.6[b]	4–8†[b]
Arachis hypogea	297 (71)[c]	82[c]	4[c]	8§[c]	0.5[c]	13†[c]
Bidens pilosa	163–222 (39–53)[a,b,d]	85–88[a,b,d]	3–5[a,b,d]	3–6§[a,b,d]	0.4–0.6[a,b,d]	2‡[d], 8†[a,b]
Brassica sp.	100–142 (24–34)[c]	92–94[c]	1–2[c]	2–4§[c]	0.1–0.3[b]	5–6†[c]
Ceratotheca triloba	259 (62)[b]	85[b]	2[b]	2§[b]	2.1[b]	8†[b]
Chenopodium album	212–247 (44–59)[b,d]	83–85[b,d]	4–5[b,d]	2§[b,d]	0.8[b]	2‡[d], 8†[b]
Cleome sp.	142–218 (34–52)[a,b,d]	85–88[a,b,d]	5[a,b,d]	1–5§[a,b,d]	0.3–0.9[a,b,d]	2‡[d], 5†[a,b]
Cucurbita pepo	109 (26)[d]	93[d]	3[d]	2§[d]	0.7[d]	0.4‡[d]
Emex australis	151 (36)[b]	89[b]	5[b]	2§[b]	0.6[b]	3†[b]
Galinsoga parviflora	171 (41)[b]	89[b]	4[b]	1§[b]	0.5[b]	5†[b]
Ipomoea batatas	188–276 (45–66)[a,c,d]	83–88[a,c,d]	4–5[a,c,d]	2–5§[a,c,d]	0.2–1.1[a,c,d]	4‡[d], 10†[c]
Justicia flava	213 (51)[b]	84[b]	3[b]	1§[b]	0.4[b]	9†[b]
Lesianthera africana	305 (73)[e]	77[e]	3[e]	4**[e]	1.1[e]	–
Manihot esculenta	381 (91)[b]	72[b]	7[b]	4§[b]	1.0[a]	18†[b]
Momordica sp.	222 (53)[a]	85[a]	5[a]	3§[a]	5.0[b]	7†[a]
Portulaca oleracea	96 (23)[b]	93[b]	3[b]	1§[b]	0.3[b]	3†[b]
Senna occidentalis	351 (84)[b]	77[b]	7[b]	3§[b]	2.2[b]	9†[b]
Solanum sp.	228–241 (55–58)[b,d,g]	83–90[b,d,g]	3–5[b,d,g]	1**[g], 2–6§[b,d]	0.6[b]	2‡[d], 9†[b]
Spinacea oleracea	125 (30)[d]	92[d]	3[d]	3§[d]	0.4[d]	1‡[d]
Vernonia sp.	167–343 (40–82)[a,f]	79–89[a,f]	3–5[a,f]	2–5§[a,f]	–	–
Vigna unguiculata	180 (43)[d]	86[d]	5[d]	4§[d]	0.4[d]	2‡[d]

'§' represent dietary fibre, '**' represent crude fibre, '†' represent carbohydrate value by difference, '‡' represent available carbohydrate, '–' represent not determined.

https://doi.org/10.1016/j.jfca.2010.05.002

Compositions with health benefits

- Carbohydrates
- Protein
- Fats
- Fibers

→ macronutrients

- Vitamin and minerals → micronutrients
- Other health-promoting compounds (e.g. phenolic compound, phytosterols, etc.)

After drying

The content of health-benefit compounds may be:

1. Unchanged
2. Decreased
3. (Possibly) increased

How to express the content of compound in sample

Fresh weight basis

$$\frac{\text{weight of compound}}{\text{weight of sample}}$$

Dry weight basis

$$\frac{\text{weight of compound}}{\text{weight of solid in s ample}}$$

How to find this?

Fiber

- not digested/absorbed carbohydrate in human gut
- Increase fecal bulk, absorb fat and cholesterol from diet
- Fiber is stable during drying
- Thus, dried fruit and vegetables increase fiber intake

What is fiber?

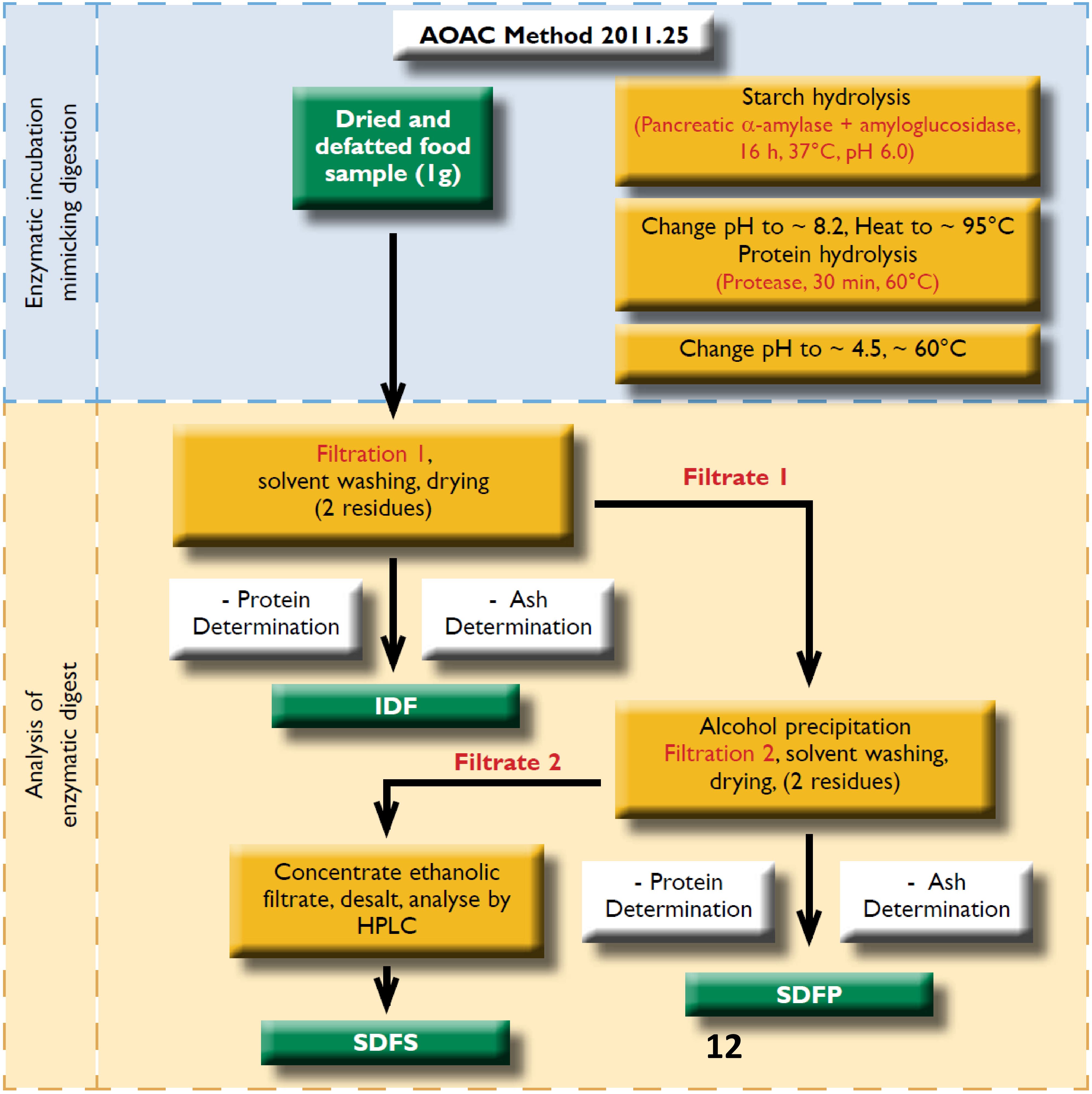
The most widely accepted definition of fiber is that proposed by the FAO Codex Alimentarius Commission in 2009. There are three key elements of the Codex definition of fiber. These are as follows: a) carbohydrate polymers of 10 or more monomeric units (with the decision on inclusion of fibers with degree of polymerization (DP) from 3–9 left to national authorities); b) not hydrolyzed by small intestine enzymes; c) could be naturally occurring or extrinsic polymers, which have been shown to have a beneficial physiological effect.

Food Technology, November 2012, Volume 66, No.11

Classification of fibers

- Soluble dietary fiber (SDF) include β-glucan, psyllium, pectins, guar gum, arabinoxylans, and inulin → beneficial effects on human organisms, such as reduction of cholesterol levels, decrease of gastric emptying and small intestine transit time, prebiotic effect, and fecal bulk effect
- Insoluble dietary fiber (IDF) include cellulose, hemicellulose, chitosan, lignin, etc., → water insolubility, decreased fermentability, and stool bulk forming

Abbreviation	Definition	Examples
HMWDF	High molecular weight dietary fiber (HMWDF = IDF + SDFP)	Cellulose, resistant starch, cereal β-glucan, guar gum and certain xylans
IDF	Dietary fiber insoluble in water	Cellulose, resistant starch and certain xylans
SDFP	Dietary fiber soluble in water and precipitated by 78% ethanol	Cereal β-glucan, guar gum and certain xylans
SDFS	Dietary fiber soluble in water and soluble in 78% ethanol. This is also sometimes termed low molecular weight dietary fiber (LMWDF) or non-digestible oligosaccharides (NDO)	Fructooligosaccharides (FOS), galactooligosaccharides (GOS) and a portion of Polydextrose®, inulin and resistant maltodextrins (RMD)



SDF= SDFS + SDFP

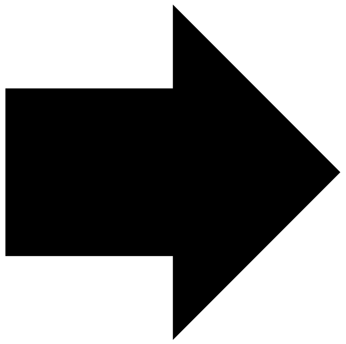
TDF = SDF + IDF

Example

Fresh pineapple
m.c. = 80% (w.b.)

Dried pineapple
m.c. = 20% (w.b.)

initial fiber content
= 1.5 g/100 g



fiber content =
1.5/25*100 = 6 g/100 g

BUT the sugar (~10%) which is also stable will also increase 4 times!

Vegetable, fruit and nuts are sources of fiber which is a good selling point of dried products


5 PORTION PACKS INSIDE!
Sunny Fruit
USDA ORGANIC
NON GMO Project VERIFIED
nongmoproject.org
ORGANIC FIGS
TENDER & JUICY
DRIED SMYRNA FIGS
Gluten Free
Good Source of Fiber
No Sugar Added
Nut Free
5 PORTION PACKS
Convenient & Mess-Free


PREMIUM QUALITY
Natural Product
mom's mango
since 1988
DRIED MANGO
The real taste of Thai mango
มะม่วงอบแห้ง สูตรน้ำตาลน้อย
MADE BY HEART
DELISH!
LOW SUGAR
100% MANGO
ไฟเบอร์สูง High in Fiber
น้ำตาลน้อย Low Sugar
ไม่ใส่สี No artificial colors
open
mom's mango
since 1988
DRIED MANGO
Natural Product
MADE BY HEART
100% MANGO
LOW SUGAR

Prebiotics

Some fibers are prebiotics

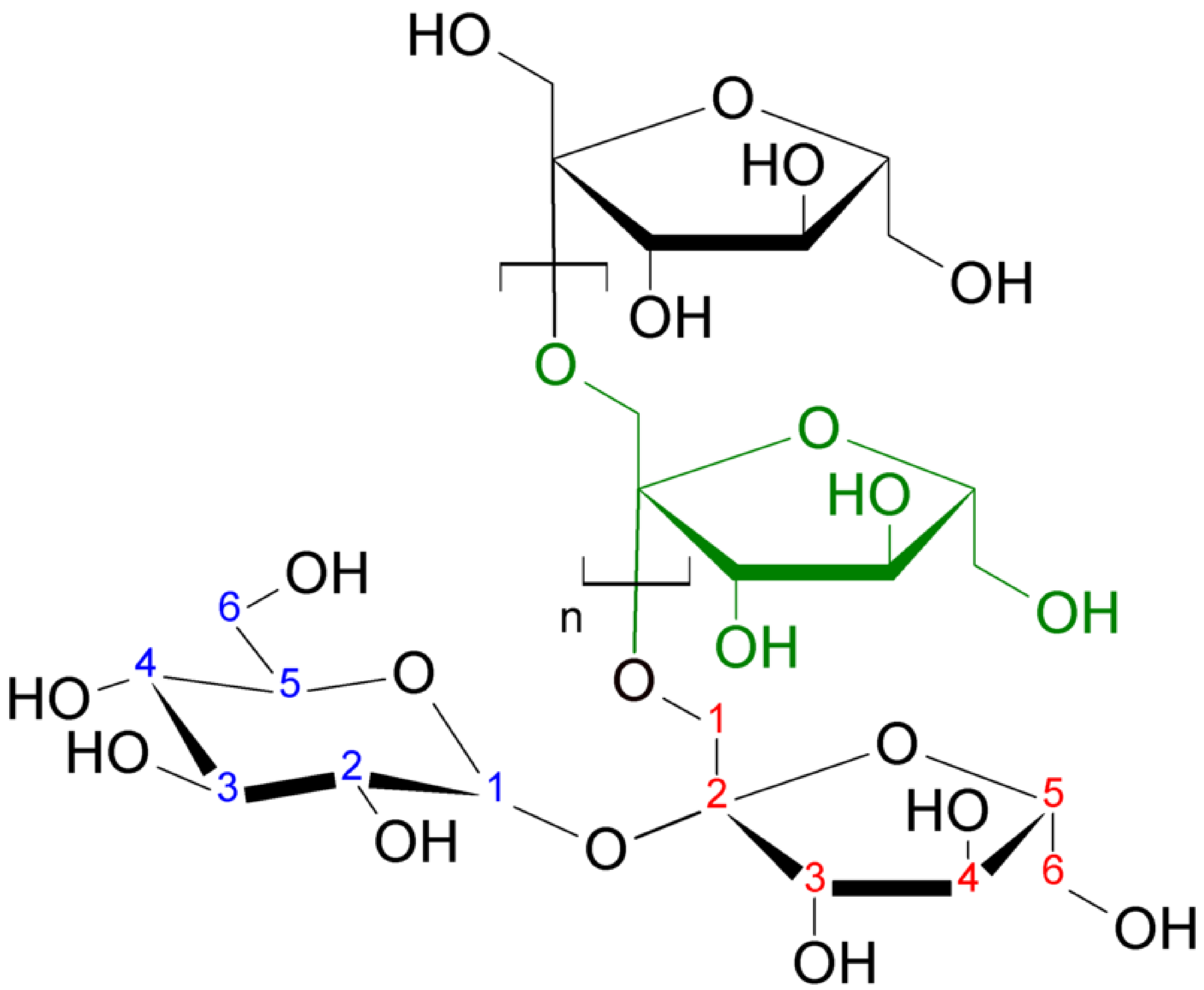
International Scientific Association of Probiotics and Prebiotics (ISAPP)

"dietary prebiotics" is "a selectively fermented ingredient that results in specific changes in the composition and/or activity of the gastrointestinal microbiota, thus conferring benefit(s) upon host health"

https://dx.doi.org/10.3390%2Ffoods8030092

Prebiotics

Sunchoke tuber is a source of "inulin", a soluble fiber which promotes growth of good bacteria in human gut (prebiotics)



Structure of inulin

The degree of polymerization (DP) of inulin can be from 2 to 60

Dried sunchoke chips

BioKing

Organic Jerusalem Artichoke Powder

Made from Jerusalem artichoke juice

- Pleasantly nutty taste
- Ideal beverage additive

Vitamins and minerals

- Vegetable and fruit are good sources of important vitamins e.g. vitamin C and vitamin A
- Meat are a good source of vitamin B and iron and zinc
- Fish and seafoods is a source of calcium, zinc, iodine
- Minerals e.g. ferric, phosphorus, calcium, potassium are stable during drying
- Stabilities of vitamins are varied
- temperature, light, oxygen are important factors affecting stability of vitamin

Recommended daily nutrient intakes (RNI) of selected micronutrients for different age groups as released by the FAO/WHO (2001).

Table 2
Recommended daily nutrient intakes (RNI) of selected micronutrients for different age groups as released by the FAO/WHO (2001).

Age (yrs)	Sex	Vitamin A (μg RE)	Vitamin C (mg)	Riboflavin (mg)	Folate (μg)	Iron[a] (mg)	Zinc[b] (mg)	Calcium (mg)	Magnesium (mg)
1–3		400	30	0.5	150	5.8	8.3	500	60
4–6		450	30	0.6	200	6.3	9.6	600	76
7–9		500	35	0.9	300	8.9	11.2	700	100
10–18	Male	600	40	1.3	400	14.6 (10–14 yrs) 18.8 (15–18 yrs)	17.1	1300	230
	Female	600	40	1.0	400	32.7 (10–14 yrs) 31.0 (15–18 yrs)	14.4	1300	220
19–65	Male	600	45	1.3	400	13.7	14.0	1 000	260
	Female	500	45	1.1	400	29.4	9.8	1 000	220

[a] Based on a diet with 10% iron bioavailability.
[b] Based on a diet with low zinc bioavailability.

https://doi.org/10.1016/j.jfca.2010.05.002

Vitamin content of selected African leafy vegetables (values per 100 g edible portion, fresh weight basis).

Table 3
Vitamin content of selected African leafy vegetables (values per 100 g edible portion, fresh weight basis).

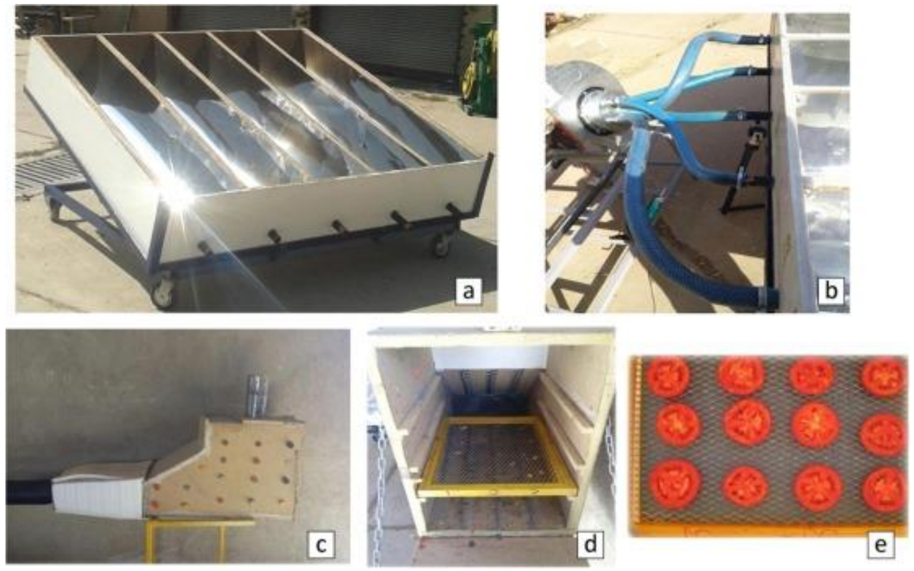
African leafy vegetables	Vitamin A (μg RE)	Ascorbic acid (mg)	Riboflavin (mg)	Folate (μg)
Adansonia digitata	–	52[b]	–	–
Amaranthus sp.	327[a]	46–126[a,c]	0.1–0.4[a,b]	64[a]
A. hypogea	–	87[d]	–	–
B. pilosa	301–985[a,b]	23[a,c]	0.2[a]	351[a]
Brassica sp.	–	30–113[a,d]	0.0–0.2[a,d]	16[a]
C. album	917[a]	31[a]	0.3[a]	30[a]
Cleome sp.	1200[a]	13–50[a,b]	0.1[a]	346[a]
Cucurbita pepo	194[a]	11[a]	0.1[a]	36[a]
I. batatas	103–980[a,b]	11–70[a,b,d]	0.3–0.4[a,d]	80[a]
M. esculenta	1970[b]	311[b]	0.6[b]	–
Momordica sp.	–	4[c]	–	–
Solanum nigrum	1070[a]	2[a]	0.3[a]	404[a]
Sonchus oleraceus	985[a]	25[a]	–	–
S. oleracea	669[a]	28[a]	0.2[a]	194[a]
Vernonia sp.	–	51–198[b,e]	0.3[a]	457[a]
V. unguiculata	99[a]	50[a]	0.2[a]	141[a]

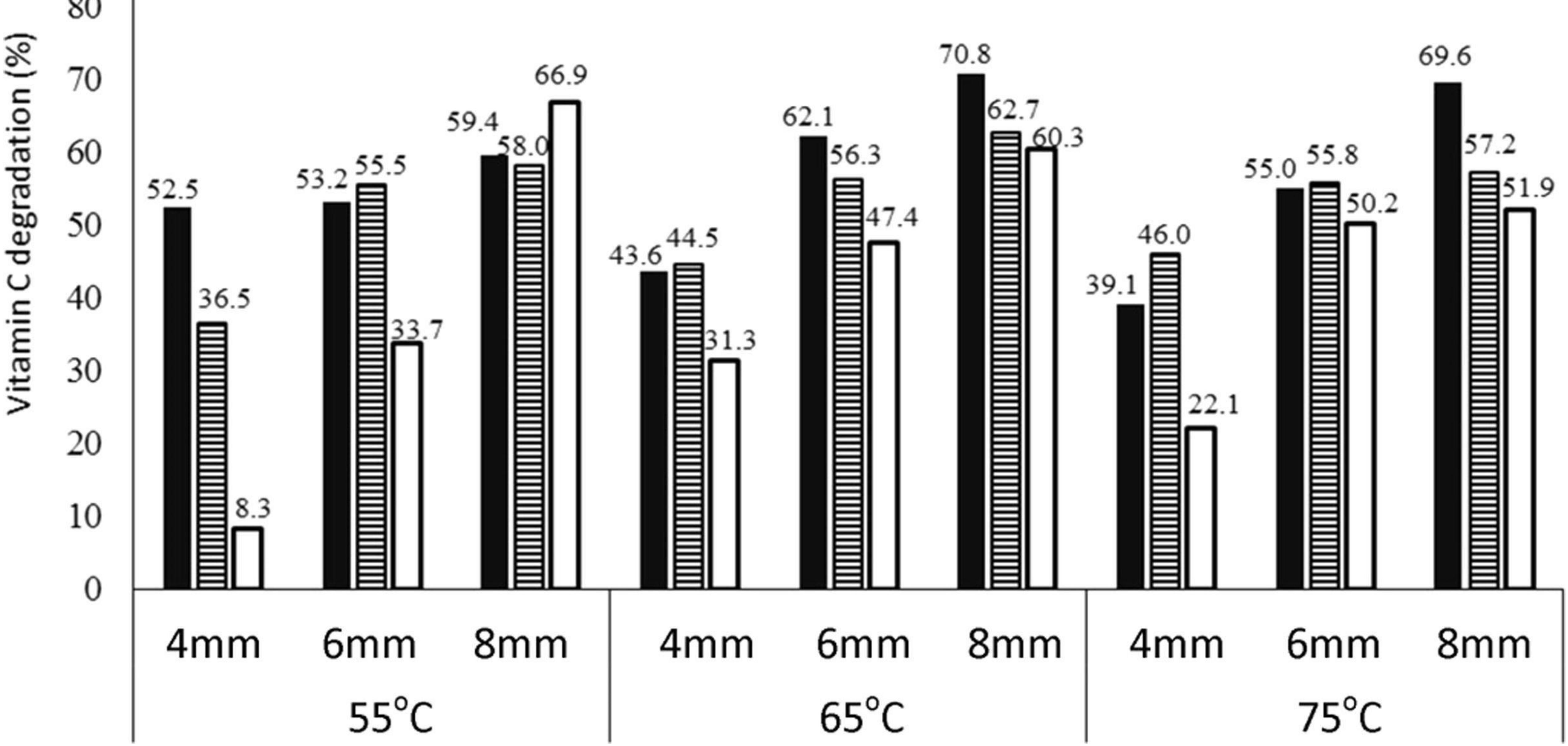
https://doi.org/10.1016/j.jfca.2010.05.002

Vitamin C

- Fruits and several vegetables contain high amount of vitamin C (ascorbic acid)
- Vitamin C tends to degrade after drying (heat, light, oxygen)
- also possibly losses during washing, blanching steps

Tomato drying using solar dryer





https://doi.org/10.1016/j.solener.2020.12.026

Effect of Blanching and Drying Methods on β -Carotene, Ascorbic acid and Chlorophyll Retention of Leafy Vegetables

Table 2 Retention of ascorbic acid (mg/100 g)* during processing

Processing condition	Savoy beet		Amaranth		Fenugreek	
	Fresh weight basis	Dry weight basis	Fresh weight basis	Dry weight basis	Fresh weight basis	Dry weight basis
Fresh Vegetable	41.3 ± 2.4	467.2 ± 23.6	68.8 ± 2.8	464.3 ± 22.9	163.5 ± 8.6	1047.4 ± 44.6
Blanching condition						
Water	10.5 ± 0.5	79.1 ± 3.8	22.7 ± 1.6	183.2 ± 9.7	56.0 ± 2.7	659.0 ± 32.2
Water and KMS	10.5 ± 0.6	70.3 ± 3.2	28.2 ± 1.5	187.6 ± 9.0	54.3 ± 2.2	572.0 ± 27.5
Salt solution	8.8 ± 0.4	67.1 ± 3.0	22.6 ± 1.2	180.8 ± 8.6	56.1 ± 2.4	511.1 ± 22.8
Salt solution and KMS	8.8 ± 0.5	63.4 ± 2.9	22.6 ± 1.4	165.6 ± 7.9	54.3 ± 2.3	474.0 ± 20.6
Mixture ($NaHCO_3$, MgO and KMS)	7.6 ± 0.4	65.1 ± 2.9	22.6 ± 1.3	193.2 ± 9.3	54.3 ± 2.7	628.0 ± 29.8
CD (0.05)	1.2	20.0	4.9	37.0	1.0	76.5
Drying condition						
Sun	11.5 ± 0.7	11.8 ± 0.7	31.6 ± 1.3	33.0 ± 1.5	128.2 ± 5.6	136.7 ± 5.9
Solar	11.9 ± 0.8	12.4 ± 0.9	34.5 ± 1.2	35.7 ± 1.5	407.8 ± 25.6	457.2 ± 29.2
Shade	20.8 ± 1.2	21.9 ± 1.6	24.7 ± 1.1	27.1 ± 1.2	250.0 ± 15.6	284.6 ± 17.4
Cabinet	14.5 ± 1.1	15.6 ± 1.2	33.0 ± 1.5	34.4 ± 1.7	480.8 ± 24.0	490.8 ± 28.9
Low temperature	34.4 ± 1.8	35.0 ± 2.1	131.6 ± 6.6	139.0 ± 7.2	461.5 ± 22.5	520.3 ± 24.8
CD (0.05)	10.3	10.6	8.7	9.2	15.9	77.9

* mean value and s_x corresponding to three replications

https://doi.org/10.1006/fstl.2000.0659

Vitamin A

- Fruit and vegetable contain “β-carotene” which can be converted into “vitamin A” in human body
- Very necessary for eyes health, protecting from vision loss and blindness
- Papaya, carrot, corn, mango, other green vegetables
- all-*trans*-β-carotene degrade into 9-*cis*-, 13-*cis*-β-carotene → lower vitamin A activity and antioxidative properties

Table 1. β-Carotene Content of Fresh and Dried Mango Flesh of Different Cultivars

samples	all-*trans*-β-carotene μg/100 g DW[c]	9-*cis*-β-carotene μg/100 g DW	13-*cis*-β-carotene μg/100 g DW	relative amount of *cis*-isomers[a] %	vitamin A value[b] RE/100 g
Kent					
fresh	4580	tr[d]	1120	24.4	142
dried[e]	4270	180	1390	36.8	752
Tommy Atkins					
fresh	3650	nd[f]	940	25.8	114
dried[e]	2510	tr[d]	930	37.1	431
Namdok Mai					
fresh	3650	tr[d]	990	27.1	121
solar-dried[g]	2400	810	730	64.2	425
Kaew					
fresh	11 680	1010	1220	19.1	423
solar-dried[g]	6820	2050	1430	51.0	1011

[a] Calculated as percentage of all-*trans*-β-carotene. [b] Retinol equivalent (RE) according to Zechmeister (*41*). [c] Dry weight. [d] In traces. [e] Standard drying process (ϑ_a = 75 °C, $a_W = 0.6$, t_D = 3–3.5 h). [f] Not detected. [g] Solar-drying process ($a_W = 0.6$, t_D = 7–8 h).

- Dried mango was found to contain high amount of beta-carotene
- Daily requirements for vitamin A are about 800 and 500 RE for healthy adults and children, respectively

https://doi.org/10.1021/jf034084h

Table 2: Percentage loss of β-carotene and vitamin C of cowpea leaf and mango fruit samples dried under solar radiation by three different methods in Uganda

Fruit/vegetable	Pro-vitamin / Vitamin	Visqueen-covered solar dryer	Polyethylene-covered solar dryer	Open-sun drying
Mango fruit	β-Carotene	73.22	84.07	94.24
	Vitamin C	53.31	66.95	84.54
Cowpea leaves (un-blanched)				
	b-Carotene	44.43	51.17	63.16
	Vitamin C	66.04	75.94	82.29
Cowpea leaves (blanched)	β-Carotene	24.49	34.42	53.37
	Vitamin C	75.77	82.03	86.15

Drying time

- Open-sun: 6 days
- Polyethylene covered: 4 days
- Visqueen-covered: 3 days

Visqueen sheet was able to protect UV more than normal PE

Ndawula, J et al. "Alterations in fruit and vegetable beta-carotene and vitamin C content caused by open-sun drying, visqueen-covered and polyethylene-covered solar-dryers." *African health sciences* vol. 4,2 (2004): 125-30.

KALE
เคล

Healthiest vegetable on earth

- ล้างสารพิษ และ ปรับสมดุลกรดด่างในร่างกาย ช่วยให้นอนหลับสนิท
- ดีต่อระบบขับถ่าย มีวิตามิน A, C, K สูงมาก
- ช่วยลดคลอเรสเตอรอล

ปริมาณที่แนะนำต่อ1หน่วยบริโภค: 1 ช้อนชา (5 กรัม)

เมนู: ใส่ในเครื่องดื่ม เช่น น้ำผัก, น้ำปั่น หรือโรยในอาหาร เช่น ผัดผัก

Remarks: ผู้ป่วยโรคไทรอยด์ไม่ควรบริโภค

Gluten Free | Milk Free | Eggs Free | Soy beans Free | Peanut Free

Effect of Blanching and Drying Methods on β -Carotene, Ascorbic acid and Chlorophyll Retention of Leafy Vegetables

Table 1 Retention of β-carotene (mg/100 g)* during processing

Processing condition	Savoy beet		Amaranth		Fenugreek	
	Fresh weight basis	Dry weight basis	Fresh weight basis	Dry weight basis	Fresh weight basis	Dry weight basis
Fresh Vegetable	7.32 ± 0.48	84.1 ± 4.3	9.79 ± 0.51	59.4 ± 4.6	5.34 ± 0.36	36.3 ± 2.4
Blanching condition						
Water	5.44 ± 0.29	41.0 ± 2.7	6.78 ± 0.43	54.9 ± 2.6	2.55 ± 0.19	29.9 ± 2.1
Water and KMS	6.25 ± 0.28	41.8 ± 2.3	8.81 ± 0.49	58.5 ± 2.2	3.17 ± 0.14	33.2 ± 1.8
Salt solution	5.11 ± 0.24	39.1 ± 2.1	7.15 ± 0.57	57.2 ± 2.1	3.00 ± 0.17	27.4 ± 1.9
Salt solution and KMS	5.26 ± 0.28	38.0 ± 1.9	7.74 ± 0.52	56.6 ± 2.3	3.55 ± 0.22	30.9 ± 2.2
Mixture ($NaHCO_3$, MgO and KMS)	4.81 ± 0.19	41.1 ± 2.5	6.66 ± 0.66	56.8 ± 2.5	2.78 ± 0.21	31.8 ± 2.4
CD (0.05)	0.58	6.0	0.86	7.8	0.39	2.0
Drying condition						
Sun	26.2 ± 2.4	26.8 ± 2.5	10.3 ± 0.6	10.8 ± 0.7	14.0 ± 0.4	15.0 ± 0.5
Solar	28.6 ± 2.6	29.7 ± 2.7	11.8 ± 0.8	12.2 ± 0.9	15.9 ± 0.7	17.9 ± 0.9
Shade	22.7 ± 2.2	23.9 ± 2.3	13.3 ± 0.6	13.8 ± 0.6	14.3 ± 0.7	16.3 ± 0.9
Cabinet	28.4 ± 2.5	29.3 ± 2.6	31.3 ± 1.2	33.2 ± 1.3	25.9 ± 0.9	26.5 ± 1.0
Low temperature	32.2 ± 2.7	33.4 ± 2.9	27.3 ± 1.0	28.8 ± 1.1	27.4 ± 0.8	30.9 ± 0.9
CD (0.05)	1.4	1.4	1.4	1.5	1.8	1.8

* mean value and s_x corresponding to three replications

https://doi.org/10.1006/fstl.2000.0659

Effect of traditional open sun-drying and solar cabinet drying on carotene content and vitamin A activity of green leafy vegetables

Table 5. Retinol equivalents (RE) and percentage contribution to the recommended daily intake level of vitamin A of an edible portion of vegetable relish[a]

	Solar-dried		Open sun-dried	
Vegetable	Retinol equivalents (μg)	Contribution to daily vit. A req.[b] (%)	Retinol equivalents (μg)	Contribution to daily vit. A req.[b] (%)
Mgagani	1514	275	943	171
Amaranth	882	160	718	131
Cowpea	907	165	579	105
Sweet potato	1038	189	833	151
Pumpkin	833	152	515	94
Ngwiba	965	175	595	108
Nsonga	1066	194	799	145
Maimbe	662	120	530	96
Mean	983	179	689	125

Mulokozi, G. & Svanberg, U. Plant Foods Hum Nutr (2003) 58: 1.
https://doi.org/10.1023/B:QUAL.0000041153.28887.9c

Example of advertise of dried mango on

- Vitamin C
- Dietary fiber
- Beta-carotene

Dried vegetables for conveniences of cooking

Chemical composition, functional properties and processing of carrot—a review

Table 1 β-Carotene content of dehydrated carrots

	β-Carotene, mg/100 g	Loss of -carotene,%
Fresh carrots	39.6±0.81	–
Dehydrated carrot chops	24.7±0.73	37.0
Dehydrated carrot shreds	22.5±0.68	43.0
Carrot powder	23.9±0.24	40.0

Source: Suman and Kumari (2002)

https://doi.org/10.1007/s13197-011-0310-7

Phytochemicals as bioactive compounds

- Plants contains several other health beneficial compounds
- They are called bioactive compounds
- Antioxidant, anti-inflammatory, anticancer, etc
- Usually the effects are not immediate, some need more scientific proving
- Processed into several “dietary supplements”

Carotenoids

- Carotenoids are natural pigments give yellow, orange, red color in fruits and vegetables
- Provitamin A (beta-carotene)
- Nonprovitamin A (Lutein, Zeaxanthin, Lycopene)







SUPERFOODS from the nature
BioFinest
TOMATO POWDER
ORGANIC
USDA ORGANIC
GLUTEN-FREE NON-GMO KOSHER VEGAN
NET WT. 4 OZ (114G)


MOTHER EARTH PRODUCTS
DRIED
TOMATO POWDER
TASTE THE GOODNESS OF MOTHER EARTH PRODUCTS
Net Wt. 20oz (567g)


THRIVE
PREMIUM FREEZE DRIED
VEGGIES
Tomato Powder
FREEZE DRIED
86

Table 1. Total lycopene and *cis*-isomer content in the dehydrated tomato samples[a]

Sample	Total lycopene (μg/g dry basis)[b]	Lycopene loss (%)	All-*trans*-isomers (%)	*Cis*-isomers (%)
Fresh tomato	75.5a	0	100	0
Osmotic treatment	75.5a	0	100	0
Osmo-vac dried	73.7b	2.4	93.5	6.5
Vac-dried	73.1c	3.2	89.9	10.1
Air-dried	72.6d	3.9	84.4	16.6

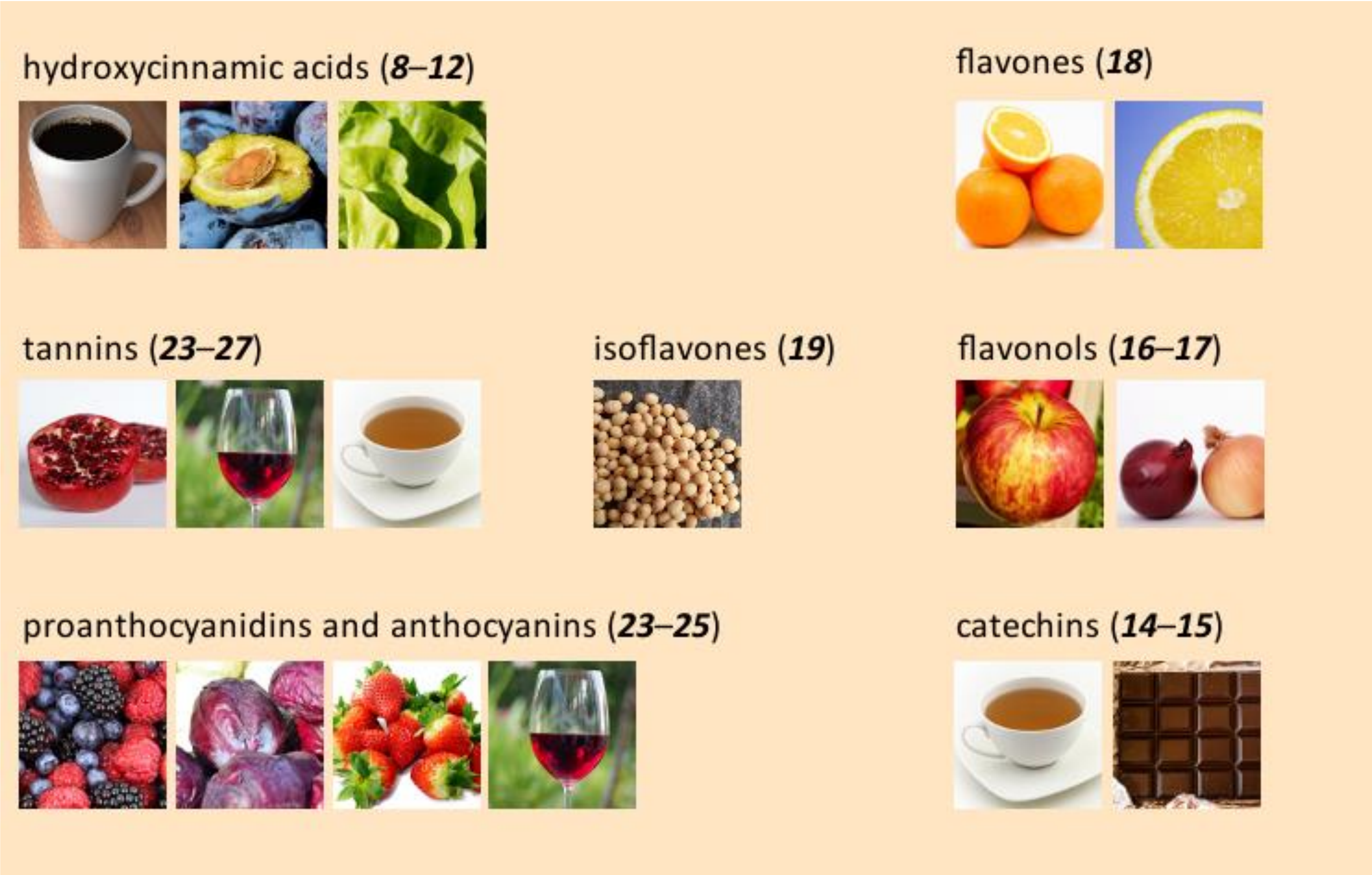
https://doi.org/10.1016/S0963-9969(99)00059-9

Phenolic compounds

- Found in all plants
- Divided in to several classes
- Possess various activities e.g. antioxidant, anti-inflammatory, reduce cholesterol etc.
- Phenolic compounds are quite stable during drying

Tea is rich in catechin

Phenolic substances in selected foodstuffs.



https://doi.org/10.1002/chemv.201700037

Anthocyanins

- One class of flavonoids
- Give purple, blue, red color
- Good antioxidant activity

purple sweet potato

butterfly pea flower

Roselle (Hibiscus)

Red cabbage

- Drink
- Colorant

Drink

Betacyanins

- betanin, prebetanin, isobetanin
- Red-flesh dragon fruit, beetroot
- Nitrogen-containing anthocyanins
- Antioxidant activity
- Quite stable during drying


SUPERFOODS from the nature
BioFinest
BEETROOT POWDER
ORGANIC
USDA ORGANIC
GLUTEN-FREE NON-GMO KOSHER VEGAN
NON GMO Project VERIFIED
VEGAN
NET WT. 4 OZ (114G)

International Journal of Food Science + Technology

Institute of Food Science + Technology ifst

International Journal of Food Science and Technology 2019, **54**, 460–470

Original article

Influence of drying conditions on colour, betacyanin content and antioxidant capacities in dried red-fleshed dragon fruit (*Hylocereus polyrhizus*)

Busarakorn Mahayothee,[1]* Nilobon Komonsing,[1] Pramote Khuwijitjaru,[1] Marcus Nagle[2,3] & Joachim Müller[2]

1 Department of Food Technology, Faculty of Engineering and Industrial Technology, Silpakorn University, Nakhon Pathom 73000, Thailand

2 Institute of Agricultural Engineering, Tropics and Subtropics Group, Universität Hohenheim, Stuttgart 70599, Germany

3 Agricultural Research and Development Program, Central State University, Ohio 45384, USA

(Received 8 June 2018; Accepted in revised form 1 September 2018)

drying of red-fleshed dragon fruit at different temperatures (40, 50, 60, 70 and 80 °C) and air velocities (1.0 and 1.5 m/s)

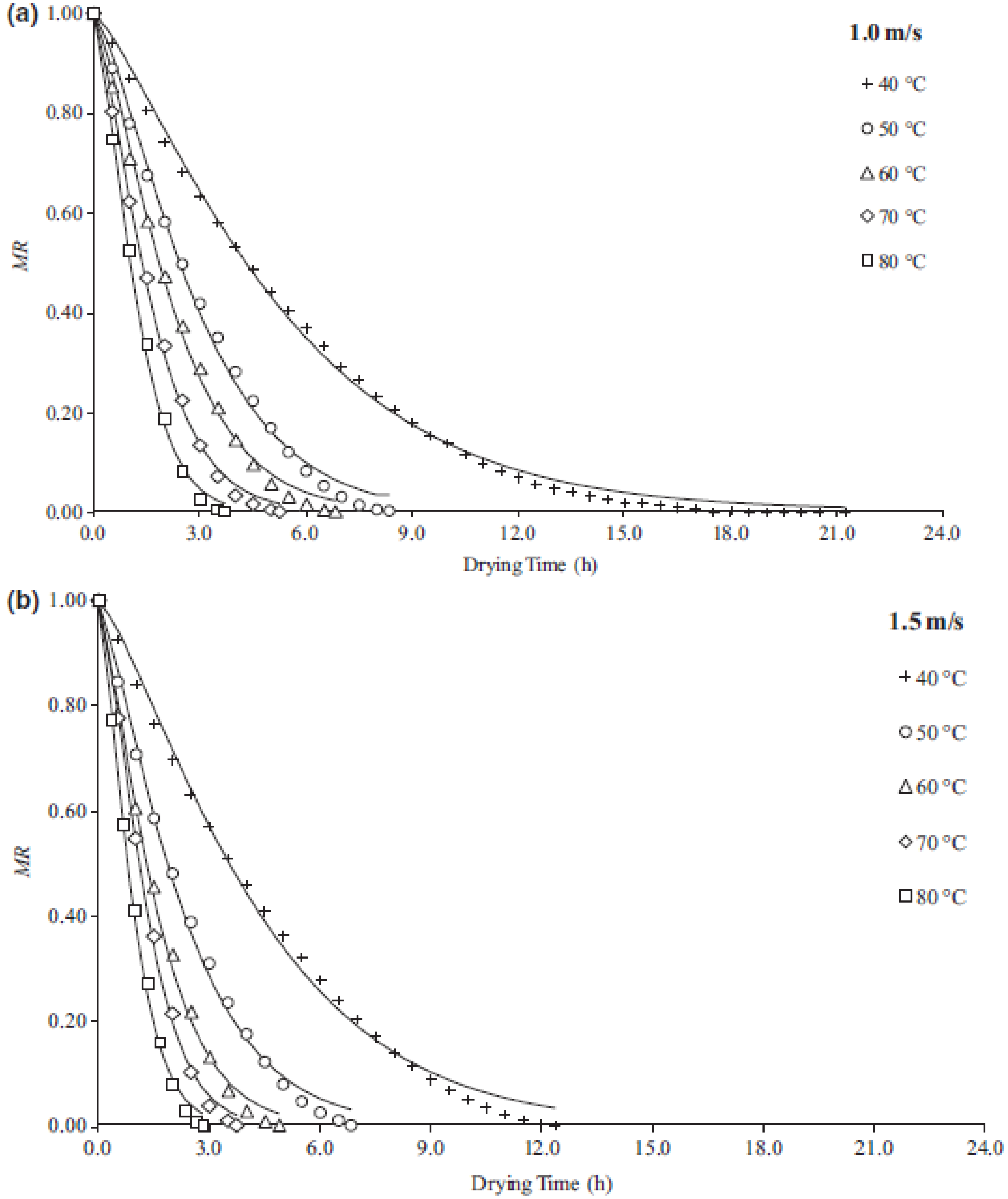
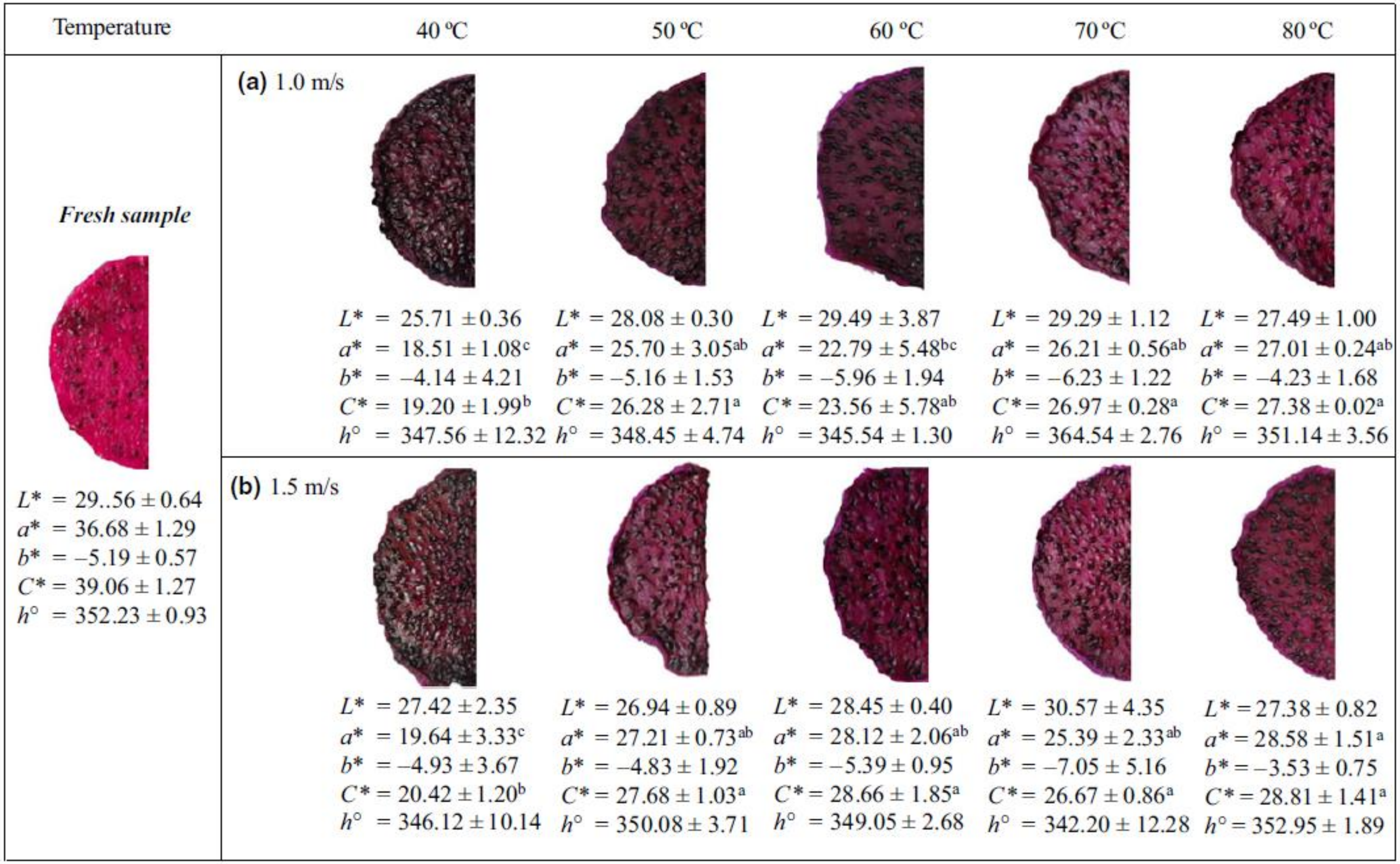
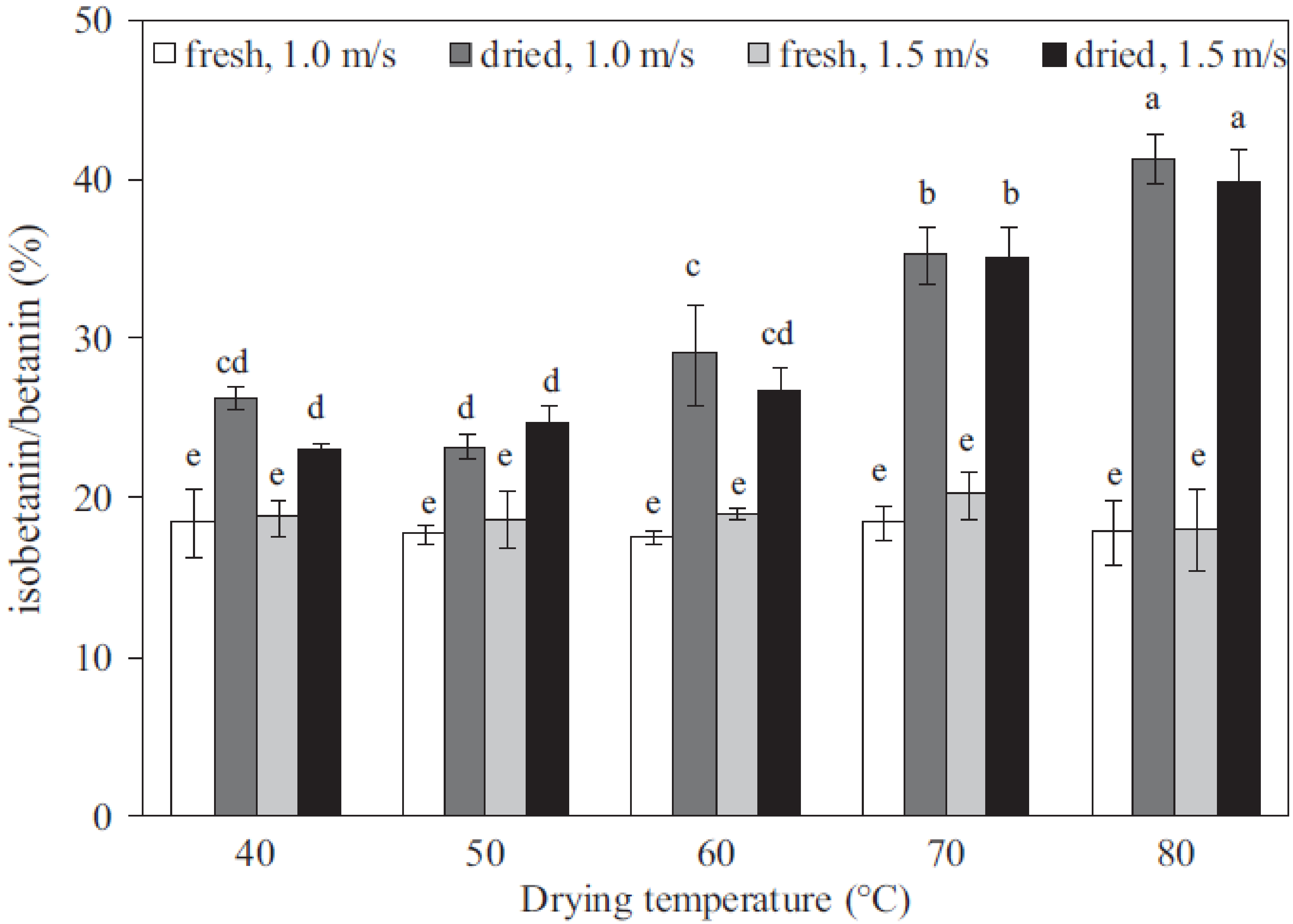


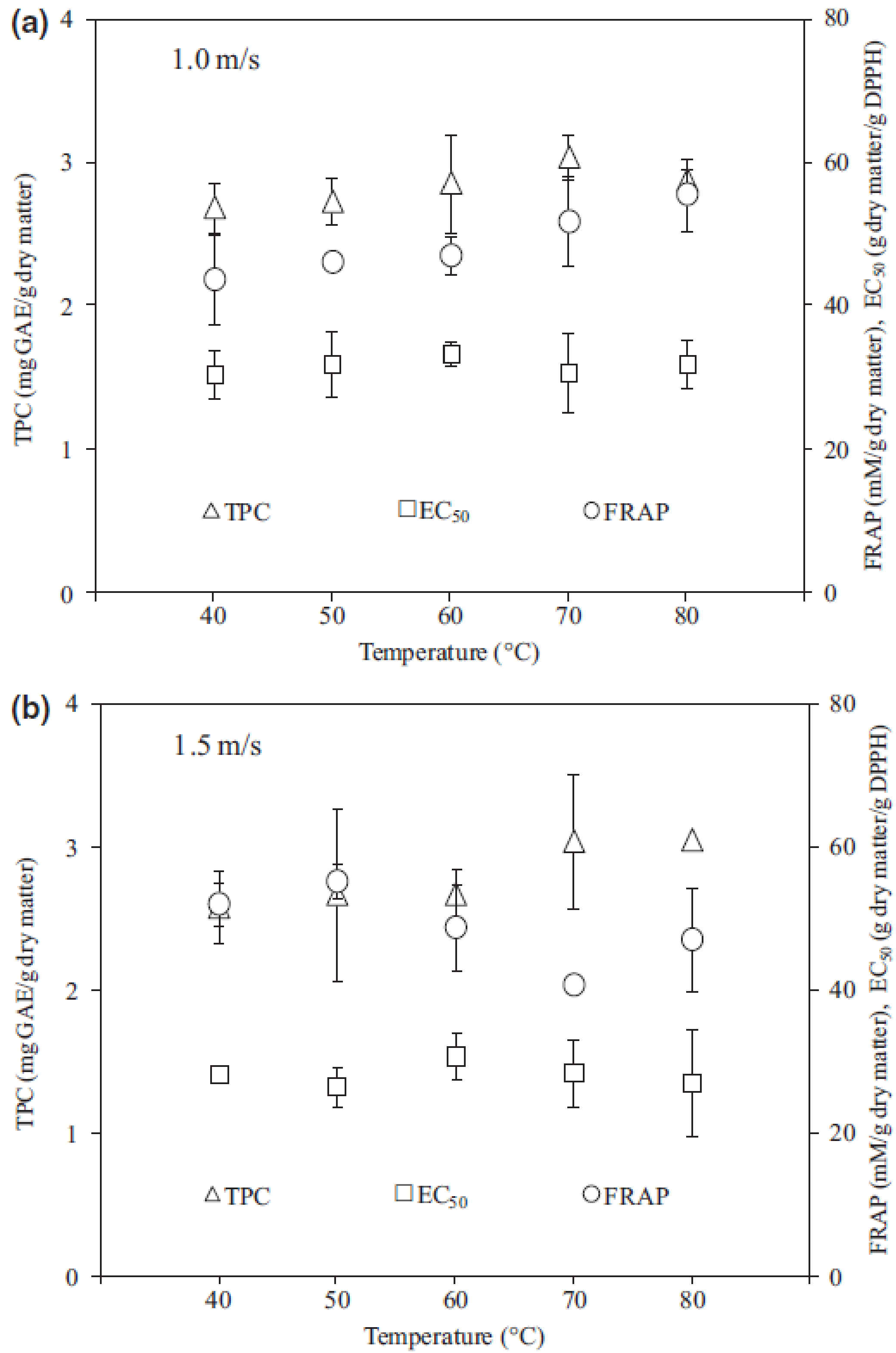
Figure 1 Drying curves of red-fleshed dragon fruit as affected by different conditions; (a) air velocity of 1.0 m s^{-1} (b) air velocity of 1.5 m s^{-1}. Temperatures are indicated by +40, ○ 50, △ 60, ◇ 70 and □ 80 °C. Lines are drawn using Page model.



Temperature
40 ºC
50 ºC
60 ºC
70 ºC
80 ºC
Fresh sample
L* = 29..56 ± 0.64
a* = 36.68 ± 1.29
b* = –5.19 ± 0.57
C* = 39.06 ± 1.27
h° = 352.23 ± 0.93
(a) 1.0 m/s
L* = 25.71 ± 0.36
a* = 18.51 ± 1.08c
b* = –4.14 ± 4.21
C* = 19.20 ± 1.99b
h° = 347.56 ± 12.32
L* = 28.08 ± 0.30
a* = 25.70 ± 3.05ab
b* = –5.16 ± 1.53
C* = 26.28 ± 2.71a
h° = 348.45 ± 4.74
L* = 29.49 ± 3.87
a* = 22.79 ± 5.48bc
b* = –5.96 ± 1.94
C* = 23.56 ± 5.78ab
h° = 345.54 ± 1.30
L* = 29.29 ± 1.12
a* = 26.21 ± 0.56ab
b* = –6.23 ± 1.22
C* = 26.97 ± 0.28a
h° = 364.54 ± 2.76
L* = 27.49 ± 1.00
a* = 27.01 ± 0.24ab
b* = –4.23 ± 1.68
C* = 27.38 ± 0.02a
h° = 351.14 ± 3.56
(b) 1.5 m/s
L* = 27.42 ± 2.35
a* = 19.64 ± 3.33c
b* = –4.93 ± 3.67
C* = 20.42 ± 1.20b
h° = 346.12 ± 10.14
L* = 26.94 ± 0.89
a* = 27.21 ± 0.73ab
b* = –4.83 ± 1.92
C* = 27.68 ± 1.03a
h° = 350.08 ± 3.71
L* = 28.45 ± 0.40
a* = 28.12 ± 2.06ab
b* = –5.39 ± 0.95
C* = 28.66 ± 1.85a
h° = 349.05 ± 2.68
L* = 30.57 ± 4.35
a* = 25.39 ± 2.33ab
b* = –7.05 ± 5.16
C* = 26.67 ± 0.86a
h° = 342.20 ± 12.28
L* = 27.38 ± 0.82
a* = 28.58 ± 1.51a
b* = –3.53 ± 0.75
C* = 28.81 ± 1.41a
h° = 352.95 ± 1.89



Heat induced isomerization of betanin to isobetanin



Antioxidant and phenolic content did no change after drying

Figure 6 Total phenolic contents (△), EC_{50} (□) and FRAP values (○) of red-fleshed dragon fruit as affected by different conditions; (a) air velocity of 1.0 m s^{-1} (b) air velocity of 1.5 m s^{-1}.

An idea of dried fruits with peel to increase maintain the bioactive compounds in the peels

Germinated rice contains high content of GABA

γ-Aminobutyric acid, or GABA is the primary inhibitory neurotransmitter in the brain → anti-anxiety

Medicinal plant

Moringa
(Moringa oleifera)

Vitamin A, C, Protein

https://doi.org/10.1016/j.fshw.2016.04.001

Moringa tea

Moringa powder

TABLE 1 Effects of drying on the phytochemical constituents of *Moringa oleifera* leaf

Parameters	Freeze-dried (mg/g)	Air-dried (mg/g)	Sun dried (mg/g)	Oven dried (mg/g)
Phenolics	68.75 ± 0.00^{d}	59.38 ± 0.42^{c}	50.00 ± 0.00^{ab}	46.88 ± 1.42^{a}
Flavonoid	62.50 ± 0.89^{d}	58.33 ± 0.00^{cd}	45.83 ± 0.89^{b}	25.00 ± 0.00^{a}
Vitamin C	52.94 ± 0.31^{d}	41.17 ± 0.31^{c}	35.29 ± 0.63^{bc}	23.53 ± 0.60^{a}
Tannin	0.06 ± 0.03	0.05 ± 0.02	0.05 ± 0.03	0.05 ± 0.03
Phytate	70.26 ± 2.40^{c}	89.82 ± 0.98^{d}	60.98 ± 0.00^{ab}	58.50 ± 1.42^{a}
Saponin	16.36 ± 0.92^{c}	16.36 ± 0.00^{c}	10.91 ± 0.82^{b}	7.27 ± 0.71^{a}
Alkaloid	12.8 ± 1.71^{c}	13.4 ± 0.00^{c}	5.00 ± 0.92^{a}	10.6 ± 2.41^{b}
Oxalate	9.96 ± 0.84^{c}	9.09 ± 0.72^{c}	6.66 ± 0.00^{a}	8.19 ± 0.60^{b}
Cardenolides	13.68 ± 0.71^{b}	11.72 ± 1.90^{b}	12.53 ± 2.40^{b}	8.17 ± 1.71^{a}
Cardiac glycosides	17.36 ± 1.31^{b}	16.72 ± 1.91^{b}	14.79 ± 2.81^{a}	14.79 ± 1.82^{a}

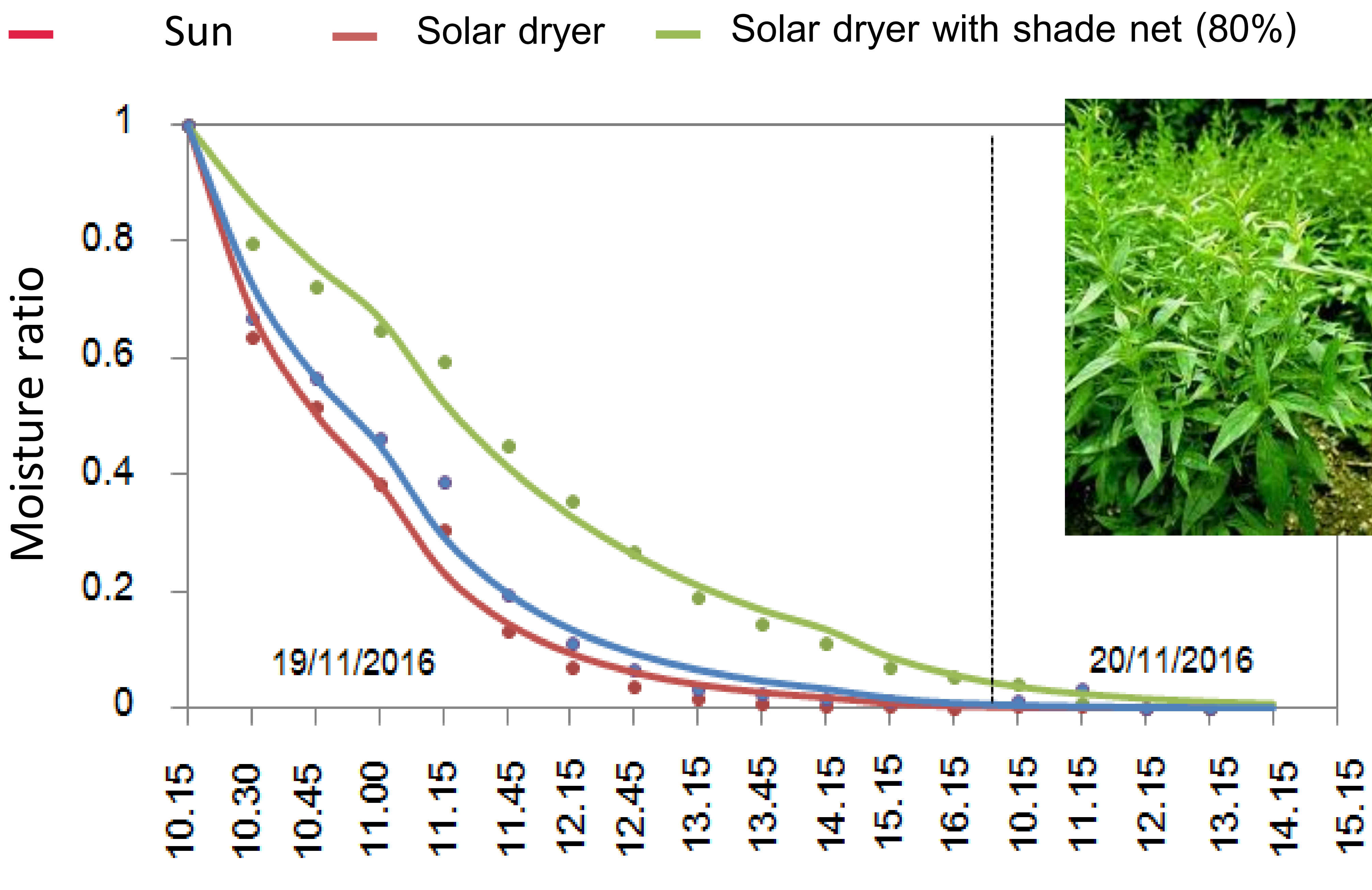
Note. Values represent mean ± standard deviation of triplicate experiments. Superscripts with different alphabets along the same row are significantly ($p < 0.05$) different.

https://dx.doi.org/10.1002%2Ffsn3.770

Example of presentation of the nutrient and bioactive compounds of product

Retention of bioactive compounds in medicinal plant/herb after drying in parabola solar dryer

Green chiretta or Kariyat (*Andrographis paniculata*) Fah-Talai-Jon



Dr. Busarakorn’s unpublished data

Dried green Kariyat

Sun

Solar dryer

Solar dryer with shade net (80%)

Dr. Busarakorn's unpublished data

green Kariyat contains andrographolide which a bioactive effective for treatment of common cold and even COVID-19 patient with mild symptoms

Sample	Andrographolide (mg/100 g DW sample)	%change[ns]
Fresh	3842.58±57.69[b]	-
Sun	2548.68±45.5[a]	-36.27±7.77
Solar dryer	2964.07±1578.93[ab]	-21.83±41.63
Solar dryer with shade net (80%)	2657.45±775.20[a]	-30.61±17.64

Dr. Busarakorn's unpublished data

Journal of Applied Research on Medicinal and Aromatic Plants 18 (2020) 100262

Contents lists available at ScienceDirect

Journal of Applied Research on Medicinal and Aromatic Plants

journal homepage: www.elsevier.com/locate/jarmap

Effect of drying temperature and drying method on drying rate and bioactive compounds in cassumunar ginger (*Zingiber montanum*)

Busarakorn Mahayothee[a,*], Thipharat Thamsala[a], Pramote Khuwijitjaru[a], Serm Janjai[b]

[a] *Department of Food Technology, Faculty of Engineering and Industrial Technology, Silpakorn University, Nakhon Pathom 73000, Thailand*

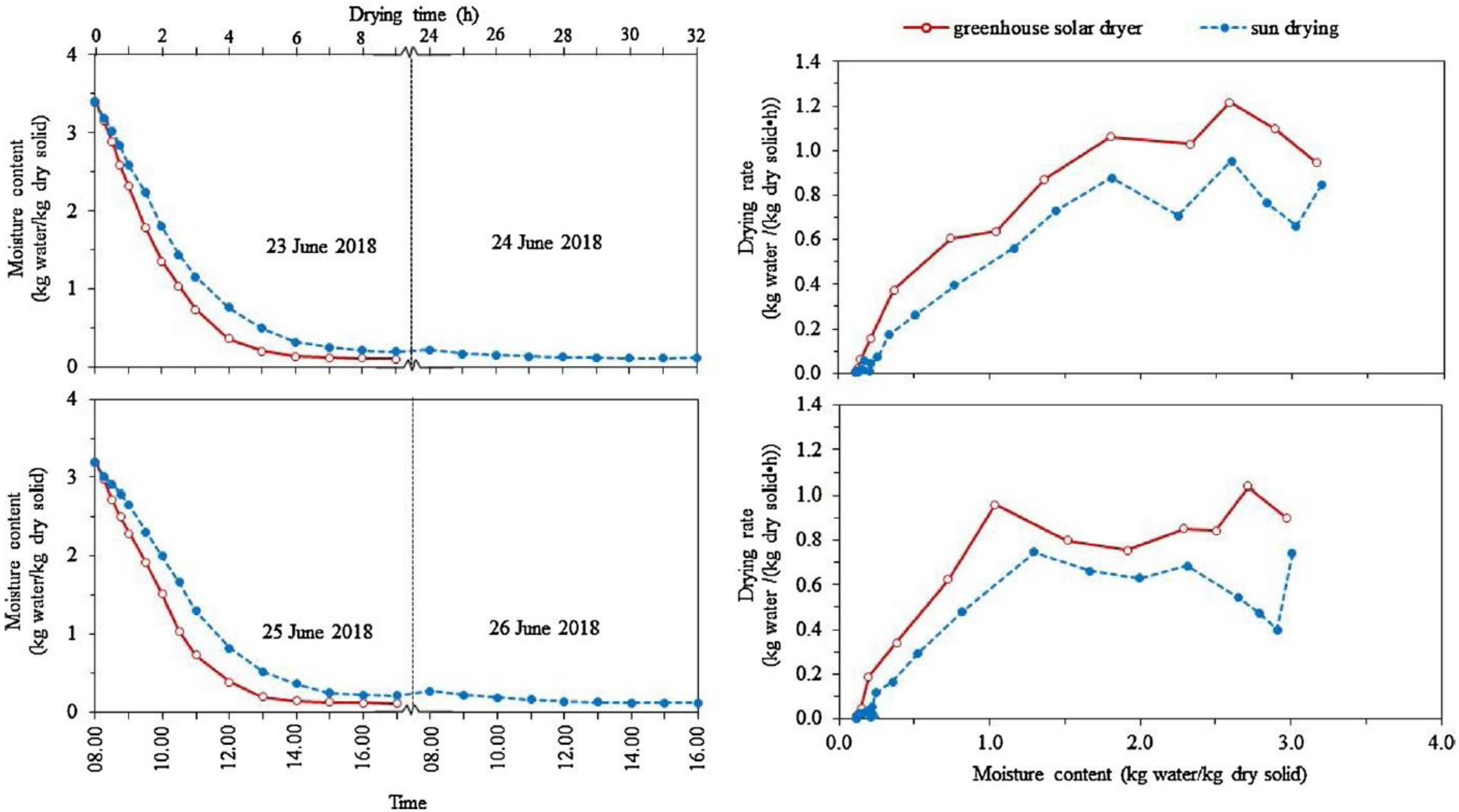
[b] *Solar Energy Research Laboratory, Department of Physics, Faculty of Science, Silpakorn University, Nakhon Pathom 73000, Thailand*

drying of cassumunar ginger (*Zingiber montanum*) slices using a hot air dryer at 40, 50, 60, 70, and 80 °C, a large-scale greenhouse solar dryer, and sun drying

“Plai”

“Plai oil” as a muscle pain relief oil

https://doi.org/10.1016/j.jarmap.2020.100262



. 2. Drying curves (A) and drying rate (B) of cassumunar ginger slices in the greenhouse solar dryer and the sun drying. Two replications are presented separately
: to the nature of the method.

https://doi.org/10.1016/j.jarmap.2020.100262

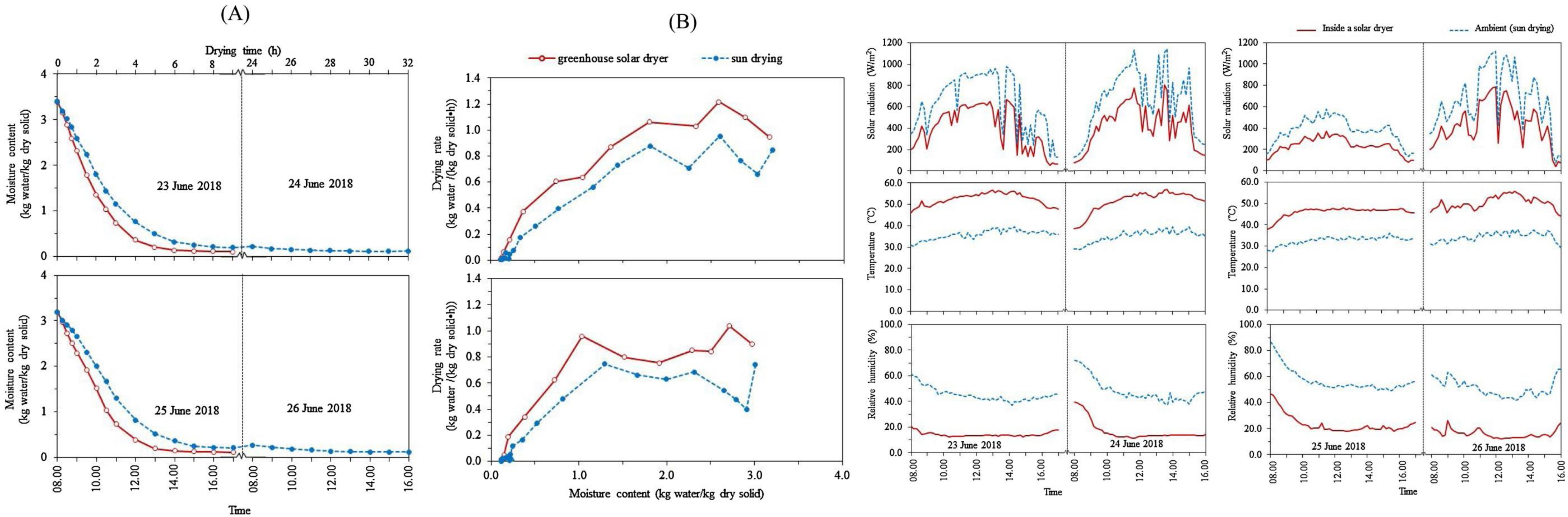


Table 3

Curcumin, compound D, and essential oil yields of the fresh and dried cassumunar gingers as affected by drying conditions.

Drying method	Curcumin (mg/g d.b.)		Compound D (Relative peak area)		Oil yield (mL/100 g d.b.)	
	Fresh^{ns}	Dried	Fresh^{ns}	Dried^{ns}	Fresh^{ns}	Dried
Hot air dryer						
40 °C	4.93 ± 0.14	8.99 ± 0.44^{a}	0.20 ± 0.02	0.18 ± 0.04	11.59 ± 0.49	8.43 ± 0.27^{ab}
50 °C	4.25 ± 0.46	8.24 ± 1.06^{ab}	0.22 ± 0.03	0.21 ± 0.03	10.66 ± 0.27	8.77 ± 0.50^{ab}
60 °C	4.65 ± 0.02	7.66 ± 0.60^{bc}	0.20 ± 0.01	0.22 ± 0.01	11.3 ± 0.55	9.28 ± 0.18^{a}
70 °C	4.46 ± 0.30	7.32 ± 1.03^{c}	0.20 ± 0.03	0.18 ± 0.03	11.43 ± 0.98	8.26 ± 0.41^{bc}
80 °C	4.33 ± 0.36	6.34 ± 1.00^{d}	0.21 ± 0.01	0.19 ± 0.00$_{4}$	11.85 ± 0.77	7.61 ± 0.41^{c}
Greenhouse solar dryer	3.70 ± 0.04	1.33 ± 0.10^{A}	0.21 ± 0.01	0.25 ± 0.01	10.89 ± 0.19	7.68 ± 0.15^{A}
Sun drying	3.70 ± 0.04	0.54 ± 0.04^{B}	0.21 ± 0.01	0.27 ± 0.02	10.89 ± 0.19	7.82 ± 0.04^{A}

Data are expressed as mean ± SD. Different superscript capital letters indicate significant difference between the greenhouse solar dryer and the sun drying and different lowercase letters indicate significant difference between drying temperatures ($p \leq 0.05$).

^{ns}represents not significant difference among drying methods ($p > 0.05$).

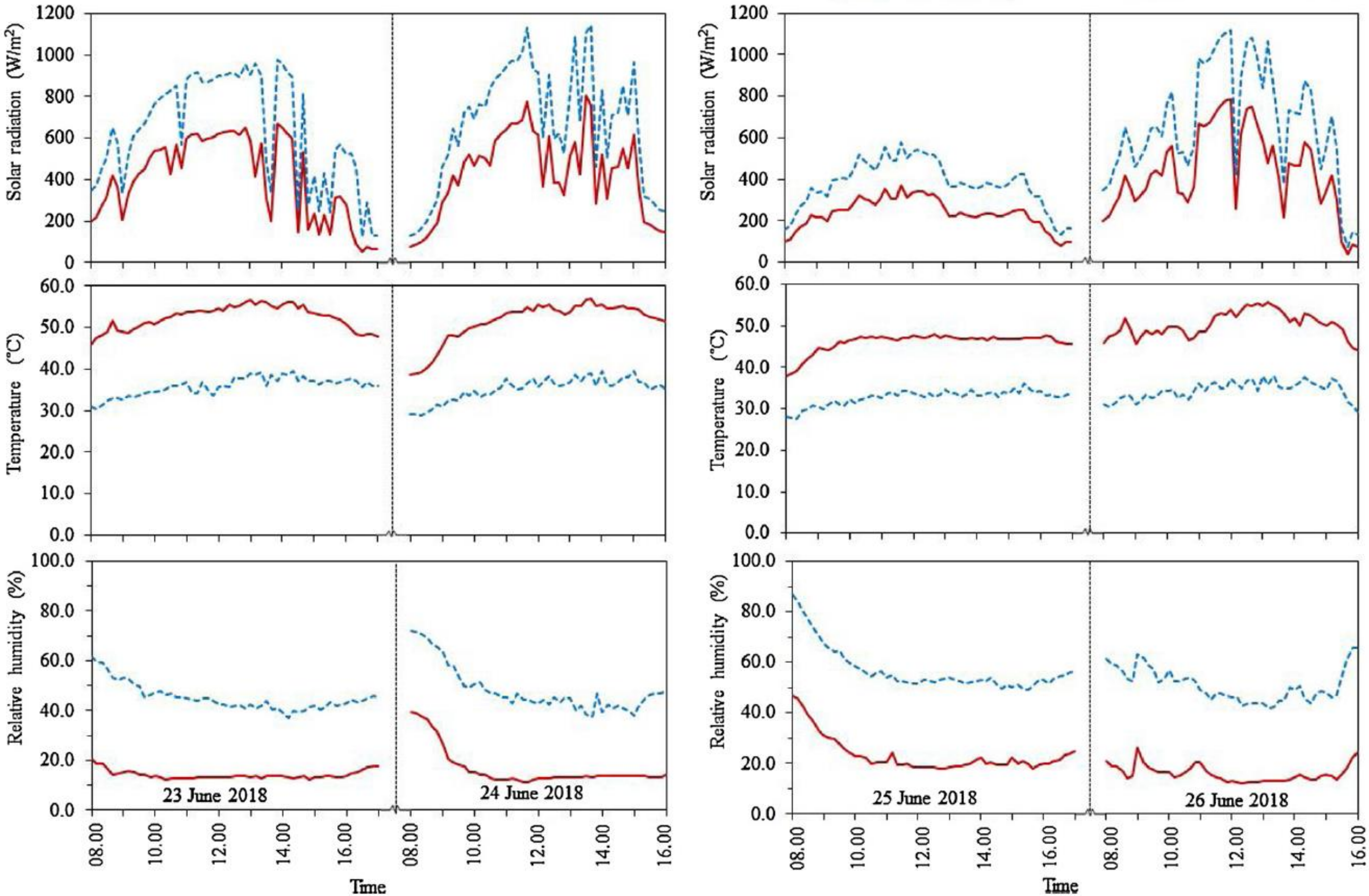
https://doi.org/10.1016/j.jarmap.2020.100262

Table 1
Drying time, moisture content, and water activity of the fresh and dried cassumunar ginger slices at the different drying conditions.

Drying method	Drying time (h)	Moisture content (% w.b.)		Water activity (a_w)	
		Fresh[ns]	Dried[ns]	Fresh[ns]	Dried
Hot air dryer					
40 °C	15	80.13 ± 2.07	10.67 ± 0.21	0.998 ± 0.001	0.499 ± 0.011[a]
50 °C	5	80.75 ± 3.39	9.53 ± 0.30	0.997 ± 0.003	0.393 ± 0.005[b]
60 °C	3	79.79 ± 1.94	10.55 ± 0.26	0.997 ± 0.000	0.412 ± 0.004[b]
70 °C	2	83.41 ± 1.38	10.33 ± 0.16	0.998 ± 0.000	0.416 ± 0.019[b]
80 °C	1.5	79.75 ± 0.81	9.44 ± 0.11	0.995 ± 0.000	0.391 ± 0.001[b]
Greenhouse solar dryer	9	77.01 ± 0.91	10.92 ± 4.91	0.995 ± 0.001	0.369 ± 0.068[A]
Sun drying	32	77.01 ± 0.91	10.69 ± 0.17	0.995 ± 0.001	0.421 ± 0.011[A]

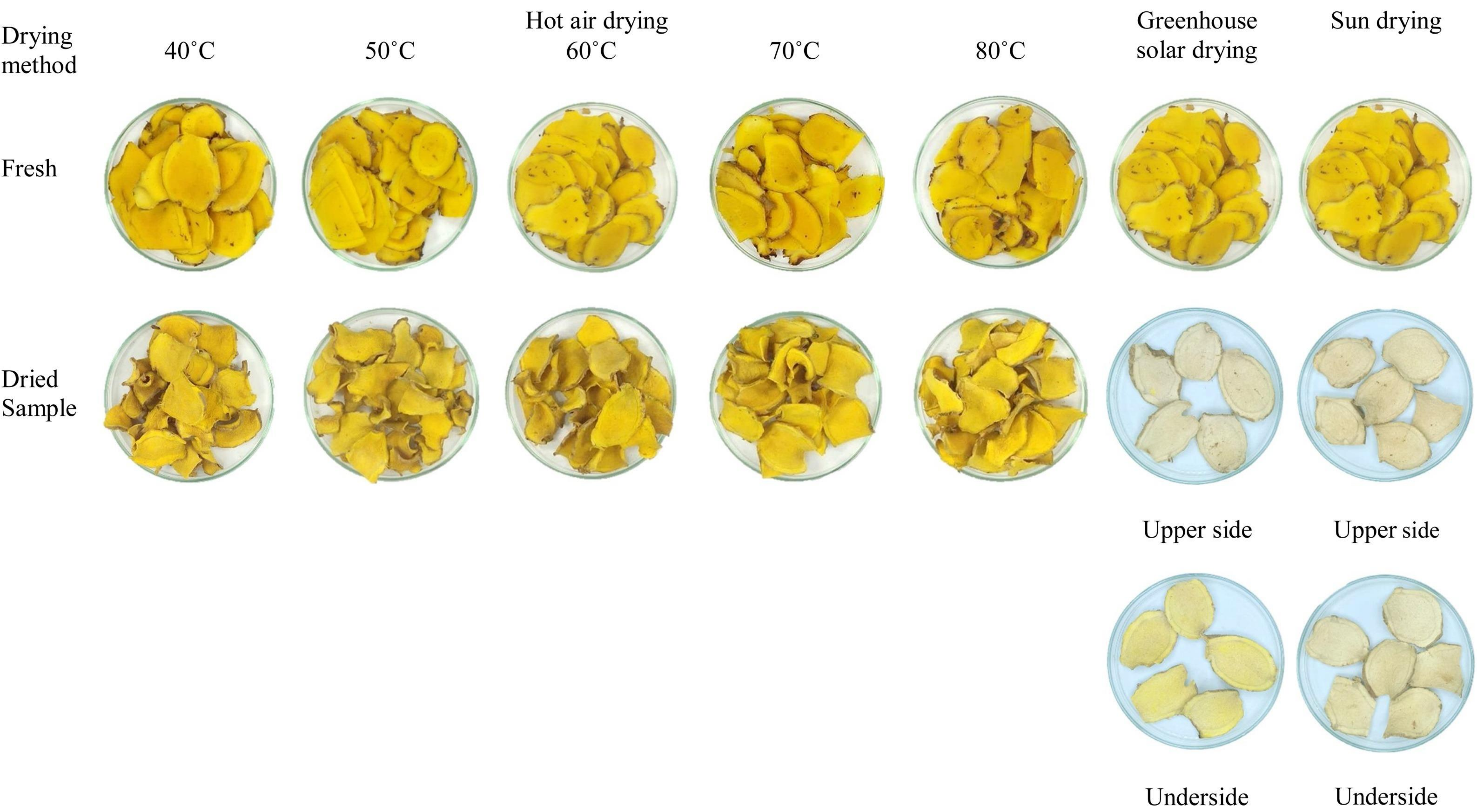
Data are expressed as mean ± SD. Different superscript capital letters indicate significant difference between the greenhouse solar dryer and the sun drying and different lowercase letters indicate significant difference between drying temperatures ($p \leq 0.05$).
[ns]represents not significant difference among drying methods ($p > 0.05$).

https://doi.org/10.1016/j.jarmap.2020.100262



https://doi.org/10.1016/j.jarmap.2020.100262

cassumunar ginger (*Zingiber montanum*)



https://doi.org/10.1016/j.jarmap.2020.100262

Table 3
Curcumin, compound D, and essential oil yields of the fresh and dried cassumunar gingers as affected by drying conditions.

Drying method	Curcumin (mg/g d.b.)		Compound D (Relative peak area)		Oil yield (mL/100 g d.b.)	
	Fresh[ns]	Dried	Fresh[ns]	Dried[ns]	Fresh[ns]	Dried
Hot air dryer						
40 °C	4.93 ± 0.14	8.99 ± 0.44[a]	0.20 ± 0.02	0.18 ± 0.04	11.59 ± 0.49	8.43 ± 0.27[ab]
50 °C	4.25 ± 0.46	8.24 ± 1.06[ab]	0.22 ± 0.03	0.21 ± 0.03	10.66 ± 0.27	8.77 ± 0.50[ab]
60 °C	4.65 ± 0.02	7.66 ± 0.60[bc]	0.20 ± 0.01	0.22 ± 0.01	11.3 ± 0.55	9.28 ± 0.18[a]
70 °C	4.46 ± 0.30	7.32 ± 1.03[c]	0.20 ± 0.03	0.18 ± 0.03	11.43 ± 0.98	8.26 ± 0.41[bc]
80 °C	4.33 ± 0.36	6.34 ± 1.00[d]	0.21 ± 0.01	0.19 ± 0.00_4	11.85 ± 0.77	7.61 ± 0.41[c]
Greenhouse solar dryer	3.70 ± 0.04	1.33 ± 0.10[A]	0.21 ± 0.01	0.25 ± 0.01	10.89 ± 0.19	7.68 ± 0.15[A]
Sun drying	3.70 ± 0.04	0.54 ± 0.04[B]	0.21 ± 0.01	0.27 ± 0.02	10.89 ± 0.19	7.82 ± 0.04[A]

Data are expressed as mean ± SD. Different superscript capital letters indicate significant difference between the greenhouse solar dryer and the sun drying and different lowercase letters indicate significant difference between drying temperatures ($p \leq 0.05$).
[ns]represents not significant difference among drying methods ($p > 0.05$).

https://doi.org/10.1016/j.jarmap.2020.100262

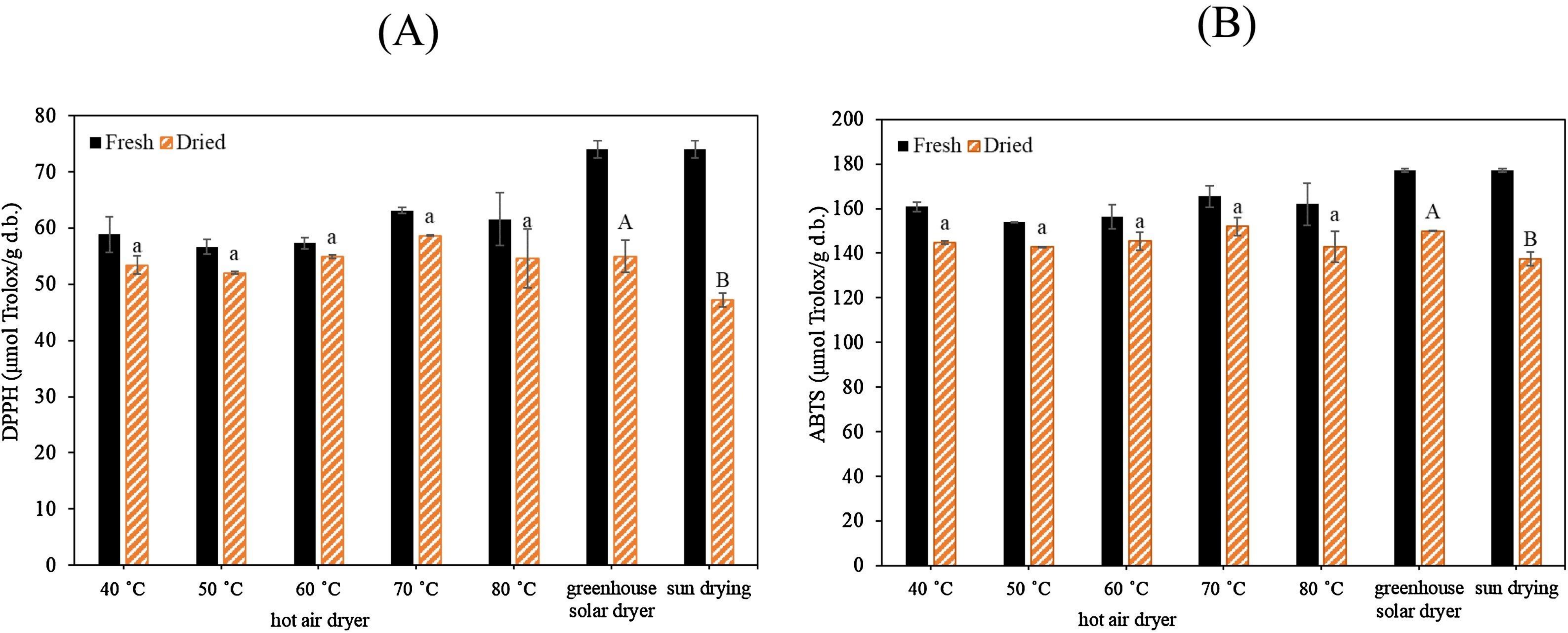


Fig. 5. Antioxidant capacities of the fresh and dried cassumunar gingers by DPPH (A) and ABTS (B) assays. Bars with different capital letters indicate significant difference between the greenhouse solar dryer and the sun drying and with different lowercase letters indicate significant difference between drying temperatures in the hot air dryer ($p \leq 0.05$).

https://doi.org/10.1016/j.jarmap.2020.100262

ELSEVIER

Contents lists available at ScienceDirect

Journal of Food Engineering

journal homepage: www.elsevier.com/locate/jfoodeng

Check for updates

Effect of drying temperature together with light on drying characteristics and bioactive compounds in turmeric slice

Nilobon Komonsing [a], Pramote Khuwijitjaru [a], Marcus Nagle [b,c], Joachim Müller [b], Busarakorn Mahayothee [a,*]

[a] Department of Food Technology, Faculty of Engineering and Industrial Technology, Silpakorn University, Nakhon Pathom, 73000, Thailand
[b] Institute of Agricultural Engineering, Tropics and Subtropics Group, University of Hohenheim, Stuttgart, 70599, Germany
[c] Agricultural Research and Development Program, Central State University, Wilberforce, OH, 45384, USA

Turmeric slices were dried at five temperatures (40, 50, 60, 70, and 80 ◦C) under two conditions (without light exposu noLE and with light exposure; LE)

https://doi.org/10.1016/j.jfoodeng.2021.110695

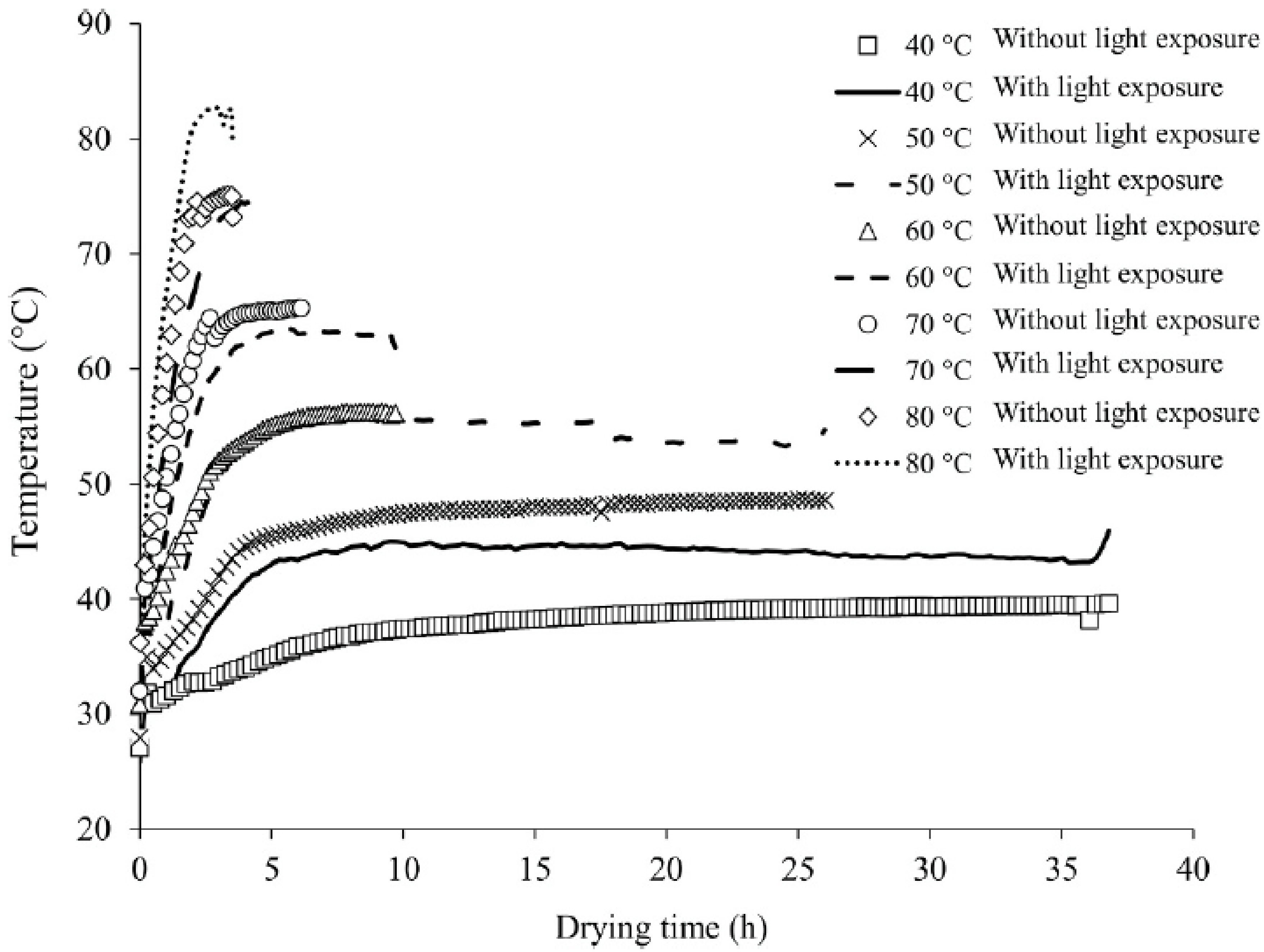


Fig. 2. Product temperature of turmeric slices during drying at different conditions.

https://doi.org/10.1016/j.jfoodeng.2021.110695

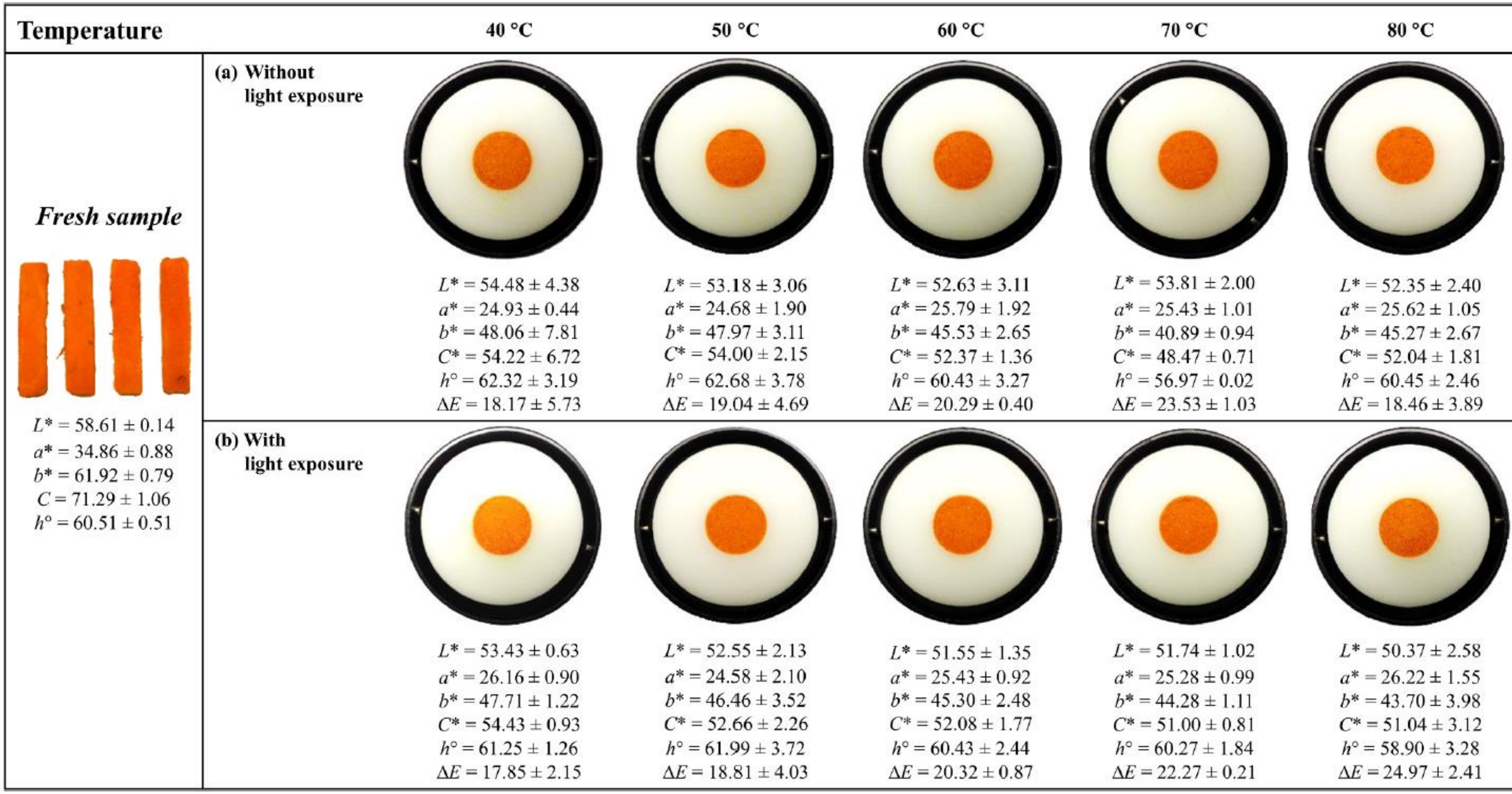


Fig. 4. Appearance and color values of fresh turmeric slices and dried turmeric powder under different drying conditions. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

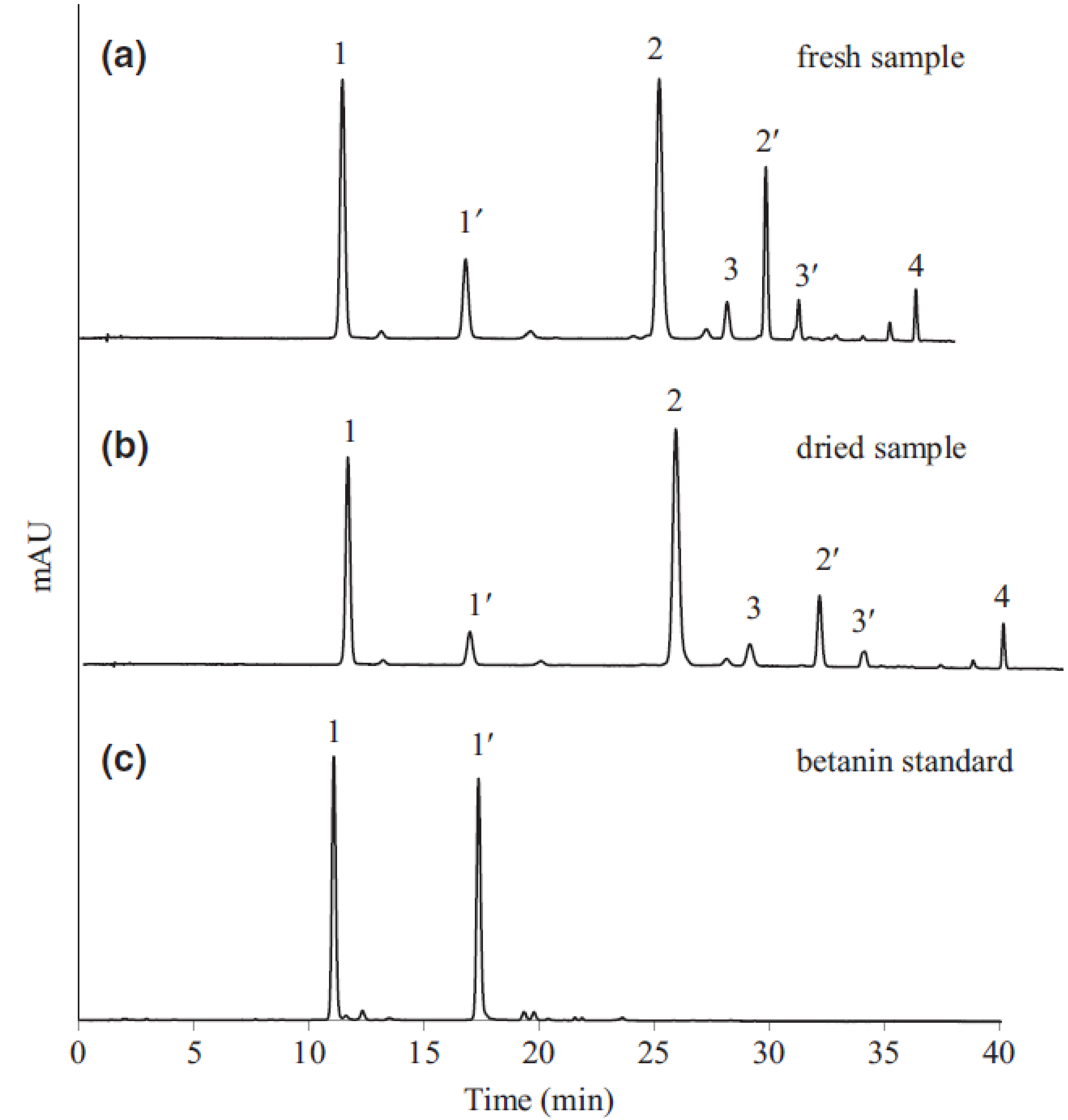


Figure 4 HPLC chromatogram of betanin standard, dried sample and fresh sample. See Table 2 for peak identification.

https://doi.org/10.1016/j.jfoodeng.2021.110695

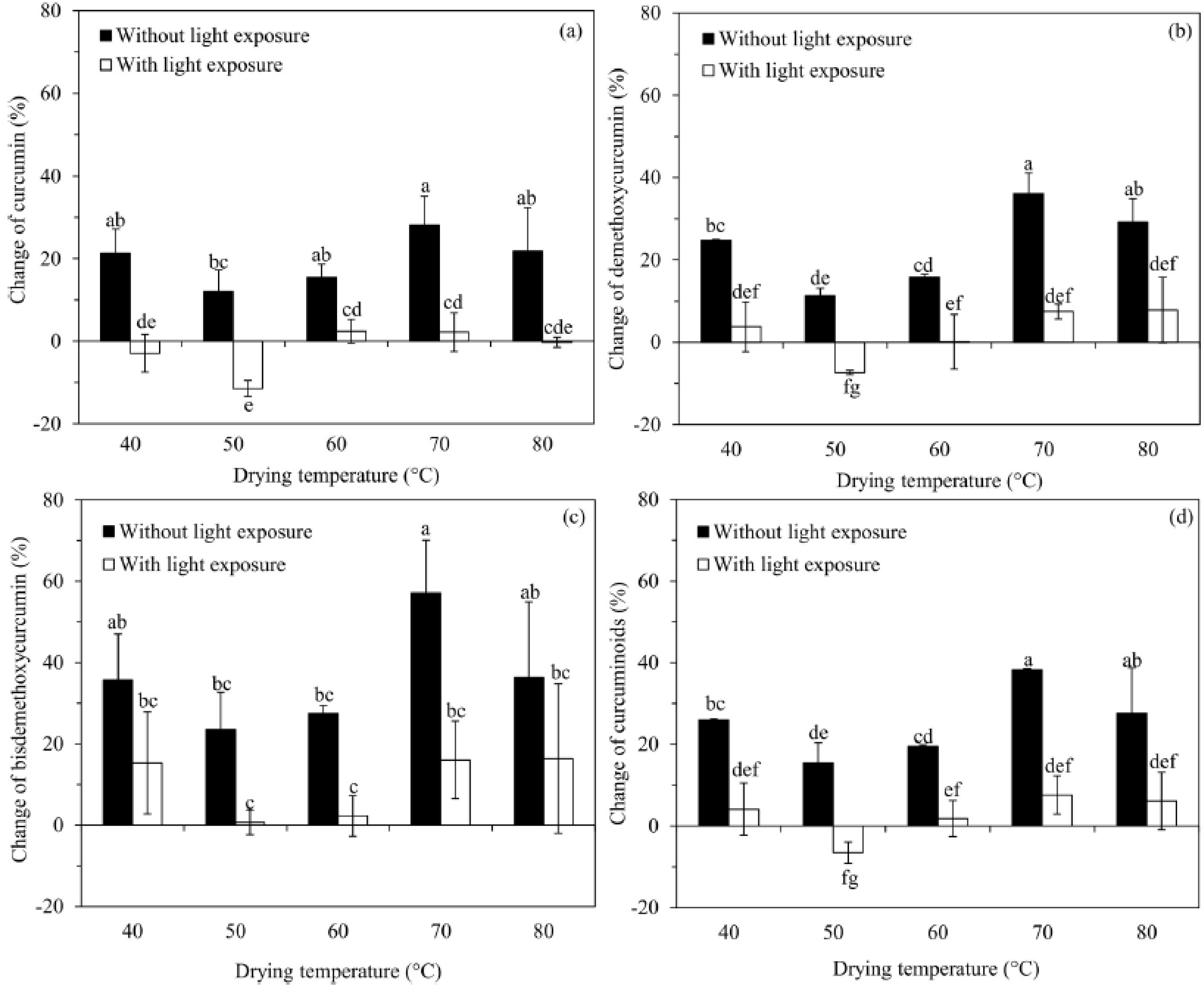


Fig. 5. Changes of (a) curcumin, (b) demethoxycurcumin, (c) bismethoxycurcumin, and (d) curcuminoids (%) of dried products as affected by drying conditions indicated by ■ without light exposure and □ with light exposure. Significant differences ($p < 0.05$) within all conditions are denoted by different letters.

https://doi.org/10.1016/j.jfoodeng.2021.110695

Drying of black galingale (*Kaempferia parviflora) rhizome*

Before drying | After drying

Fresh rhizome

Steamed rhizome

Sun drying

Greenhouse Solar dryer

Dr. Busarakorn's unpublished data

Changes in amount of 5,7 –dimethoxyflavone

Sample	Drying method	5,7-DMF (mg/100 g (d.b.)	% change
Fresh rhizome	Before drying	411.54 ±51.38[a]	
	Sun drying	1,158.49 ± 32.75[d]	184.21 ± 30.72[a]
	Greenhouse solar dryer	1,312.81 ± 57.27[c]	220.63 ± 18.46[a]
Steamed rhizome	Before drying	744.75 ± 57.71[b]	83.27 ± 36.90[b]
	Sun drying	1,214.35 ± 119.21[d]	62.92 ± 2.39[b]
	Greenhouse solar dryer	1,325.87 ± 98.89[c]	79.07 ± 19.01[b]

black galingale contains 5,7 –dimethoxyflavone which shows anti-diabetes, anti-obesity, and anti-inflammation

Dr. Busarakorn's unpublished data

Drying of germinated 'Hom nil' purple rice

sun drying

solar tunnel dryer

greenhouse solar dryer

Final moisture content of 13%

Dr. Busarakorn's unpublished data

Drying of germinated 'Hom nil' purple rice

Drying method	GABA (mg/100 g d.b.)	Anthocyanins (mg/100 g d.b.)
Shade drying	24.61 ± 2.21	14.21 ± 7.38a
Sun drying	22.27 ± 7.52	8.07 ± 4.54b
solar tunnel dryer	22.47 ± 10.28	5.34 ± 3.90b
greenhouse solar dryer	23.44 ± 2.81	7.00 ± 4.93b

Dr. Busarakorn's unpublished data

Drying of germinated 'Hom nil' purple rice

Drying method	TPC (mg GAE/100 g d.b.)	DPPH (mg Trolox 100 g d.b.)	FRAP (μmol $FeSO_4$/100 g d.b.)
Shade drying	146.82 ± 30.29a	27.80 ± 2.08a	1,447 ± 203a
Sun drying	144.25 ± 37.86a	26.48 ± 1.78ab	1,224 ± 181ab
Solar tunnel dryer	131.24 ± 25.65b	23.48 ± 3.37c	1,095 ± 153c
greenhouse solar dryer	134.32 ± 19.52b	24.15 ± 2.35ab	1,226 ± 120ab

Dr. Busarakorn's unpublished data

Conclusions

- There are several health-promoting compounds in foods
- Health promoting compounds may be unchanged, decreased or sometimes increased after drying
- In most cases, reducing direct light exposure and high temperature-shorter time seems to be a good strategy for using solar drying to dry raw materials that contains bioactive compounds
- UV-blocked cover of the solar dryer provides good protection for bioactive compounds

Thank you