Grain Processing Technologies
Class 2 – August 25th, 2017

Conventional and innovative technologies for pulse processing

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Programa de
Pós-Graduação em
Ciência e Tecnologia
de Alimentos

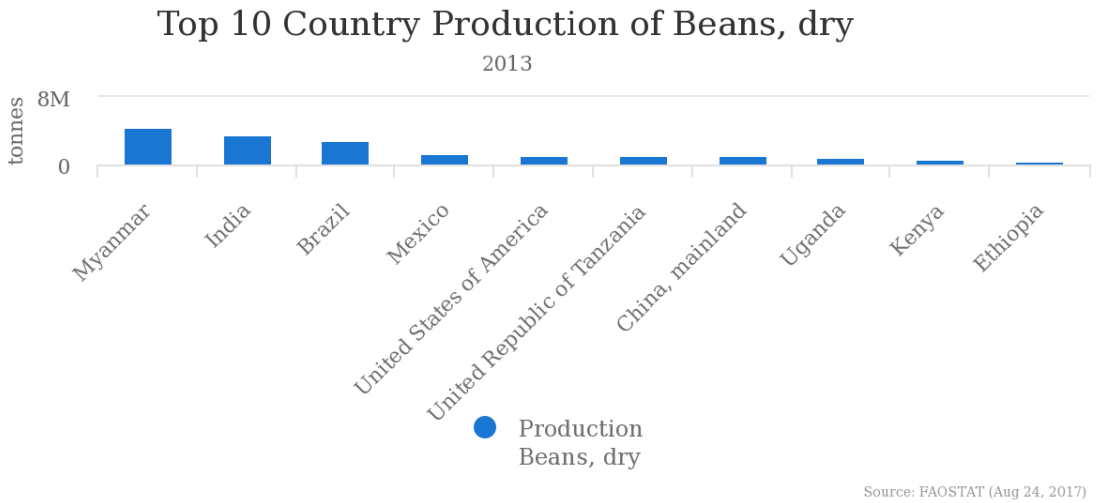
Question presented in the 1st class:

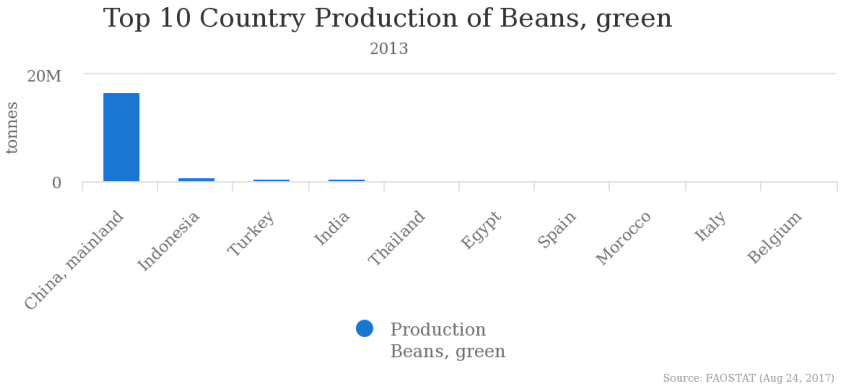
If you had to open a grain industry in Brazil, what would be your business? Why?

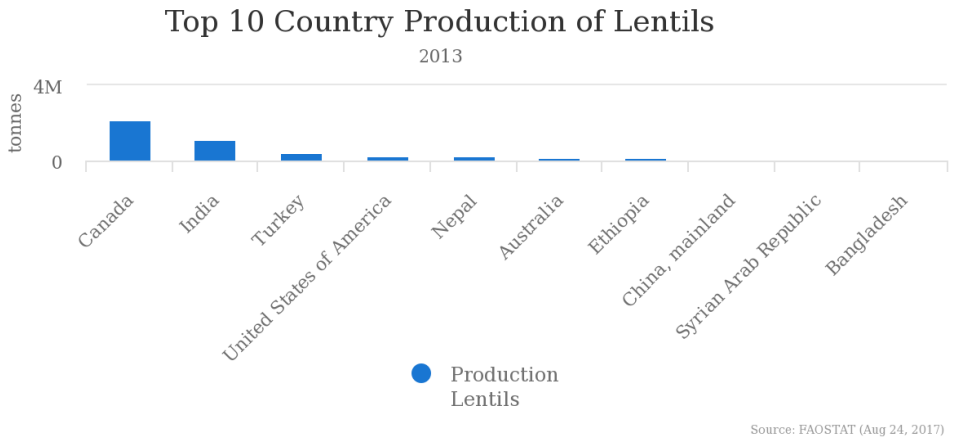
Article to be studied for today's class:

Parmar et al. (2016). Effect of canning on color, protein and phenolic profile of grains from kidney bean, field pea and chickpea. Food Res. Int., v. 89, p. 526-532.

Green beans, dry beans and lentils production







Source: FAO 2017.

Green beans

- The immature or green bean is the unripe form of the legume.

- China is the main producer of green beans worldwide.

Source: [Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.]

Green beans

- Blanching in boiling water for 3 min is necessary to make the grains edible.

Disadvantage:

- Short shelf life (freezing is an alternative)

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Dry beans

Carioca bean: Brazil.

Black bean: Brazil, Venezuela, Costa Rica, Dominican Republic, Mexico, USA e Angola.

Pinto bean: USA, Mexico, Canada, Angola, Chile, United Kingdom and other northern european countries.

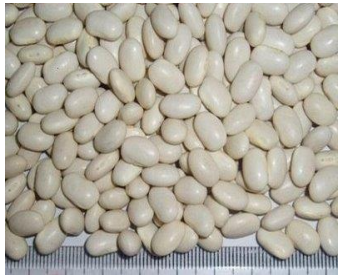
Cowpea: Brazil, India, Egipt, United Arab Emirates, Pakistan and Bangladesh.

Dry beans

Dark red kidney: Mediterraneam and northern european countries.

Light red kidney bean: Venezuela, Panama and Portugal.

Mung bean: India and Europe.



Navy bean: USA, Canada, United Kingdom, France and Italy.

Dry beans


LoveLife
Waitrose
10 Bean Mix
suitable for stews & salads or as a side dish
RICH IN FIBRE
RICH IN PROTEIN
Per 100g
Energy 461kJ 110kcal
Per 80g serving as prepared provides
Energy 369kJ 88kcal
Fat 1.0g
Saturates 0.2g
Sugars trace
Salt 0.02g
4%
1%
1%
<1%
<1%


Bob's Red Mill
FRIEND of the HEART
13 BEAN
SOUP MIX
PRIDE OF THE MILL
NET WT 29 OZ (1 LB 13 OZ) 822g
You Can See Our Quality!
39978 00251
keeps best refrigerated or frozen

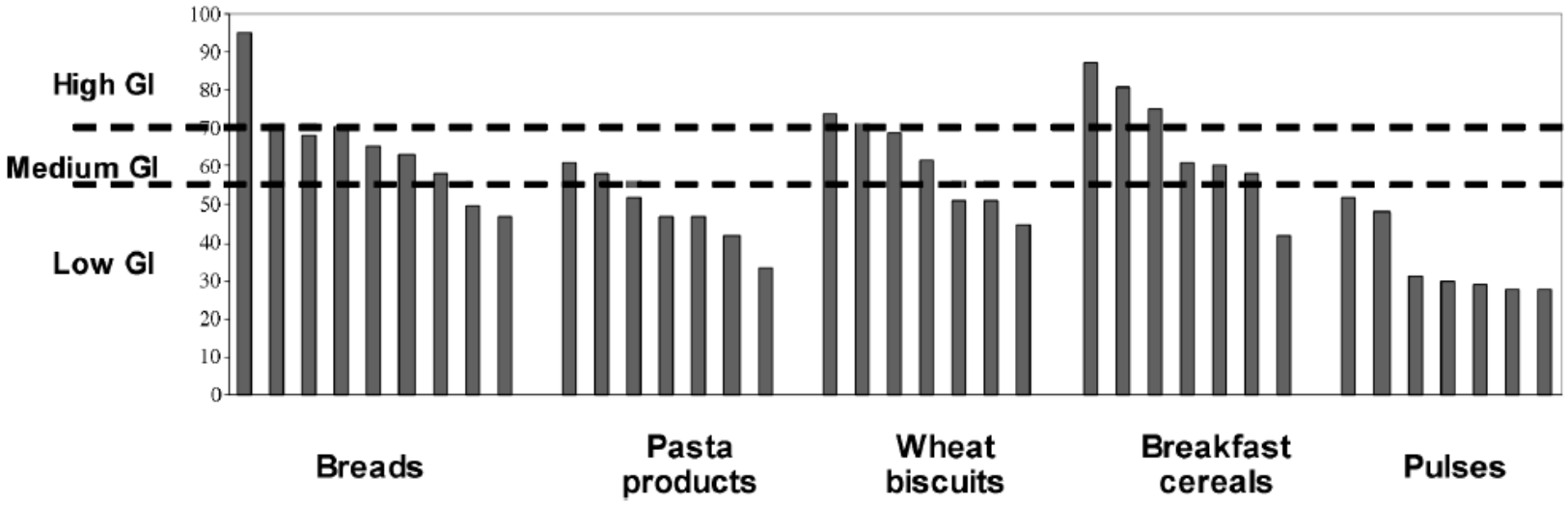
Dry beans

Not edible due to:

- Phytates
- Polyphenolics
- Enzyme inhibitors
- Hemaglutinins

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Pulses exhibit lower glycemic index than cereal and baked goods



Source: Eliasson, Starch in Food: Structure, Function and Applications, 2004, 597p.

Canned beans

Advantages of canning:

- Beans are ready to use
- High shelf life

Canned beans

How canning is performed?

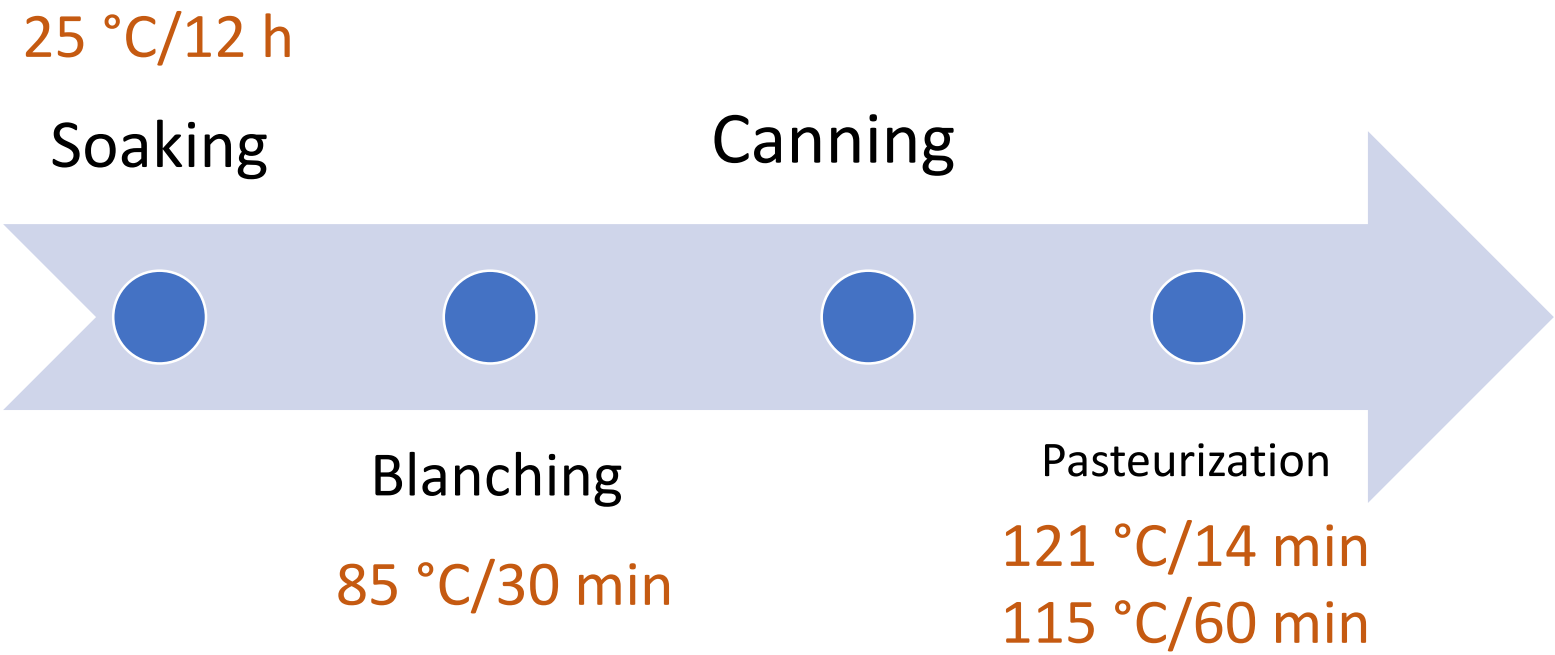
Step 1 – Beans are cleaned, selected and left to hydrate until 53-57% moisture content be achieved.

Step 2 – Soaked beans are blanched at 85 °C for 30 min in brine containing 1.3% NaCl and 1.6% sugar.

Step 3 – Blanched beans are canned and processed at 121 °C for 14 minutes.

Source: Parmar et al., Food Res. Int., v. 89, p. 526-532, 2016.

Canned beans



Source: Parmar et al., Food Res. Int., v. 89, p. 526-532, 2016.
Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Canned beans

Desirable characteristics of pulses for canning process:

- Uniform and rapid grain expansion during soaking
- High water holding capacity during processing
- Low splitting

Source: Parmar et al., Food Res. Int., v. 89, p. 526-532, 2016.

Canned beans

Chickpea main cultivars

Kabuli = Garbanzos

Desi

Smaller
Thick seed coat
Requires dehulling

Milled into a fine flour

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

“Canned baked beans”

Navy beans in tomato sauce

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Sprouted beans

- Mung bean and Chickpea are the most used pulses.
- Kabuli is preferred than Desi chickpea.

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Sprouted beans

Advantages of sprouting:

- Increase vitamin concentration
- Increase bioavailability of trace compounds and minerals
- Reduce antinutritional factores, such as stachyose and raffinose

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Sprouted beans

Glycemic index is not severely impacted by sprouting. Storage of sprouts at -4 °C favored increases in GI as compared to storage at -20 °C.

Table 3
Starch content and digestibility, expected glycemic index of fresh and stored sprouts.

		Total starch [mg/g d.m.]	Resistant starch [mg/g d.m.]	Available starch [mg/g d.m.]	Starch digestibility [%]	Expected glycemic index
Green pea	Seeds	325.5 ± 32.9d	125.4 ± 12.85d	200.2 ± 10.02d	61.49 ± 3.07a	27.61 ± 0.69a
	1F	257.8 ± 0.3c	94.9 ± 14.81c	162.9 ± 6.68bc	63.18 ± 2.21a	32.19 ± 0.80b
	2F	258.5 ± 43.7abcd	91.8 ± 23.74bcd	166.7 ± 13.34bc	64.50 ± 3.22ab	36.57 ± 0.91c
	3F	240.1 ± 46.9abcd	79.3 ± 16.93bc	160.8 ± 8.20bc	66.96 ± 2.68ab	39.31 ± 0.98d
	4F	221.0 ± 0.5a	75.9 ± 8.14bc	145.1 ± 4.50a	65.66 ± 3.28ab	39.04 ± 0.98d
	5F	218.2 ± 20.7ab	71.6 ± 20.66abc	146.6 ± 2.93a	67.18 ± 3.36ab	43.07 ± 1.08e
	6F	213.3 ± 43.8abc	59.9 ± 13.77ab	153.3 ± 4.31ab	71.89 ± 2.52bc	44.85 ± 1.12f
	3S	236.7 ± 0.2b	58.1 ± 0.05a	178.5 ± 9.10c	75.43 ± 3.77c	45.51 ± 1.14f
	4S	217.3 ± 14.8a	56.1 ± 14.78ab	161.2 ± 6.61b	74.18 ± 2.97c	46.11 ± 1.15f
	5S	213.2 ± 40.4abc	55.9 ± 10.39ab	157.3 ± 9.44ab	73.78 ± 3.69bc	75.17 ± 1.88g
Lentil	Seeds	307.8 ± 8.5e	179.7 ± 1.63d	128.1 ± 6.53b	41.62 ± 2.08a	36.00 ± 0.90a
	1F	283.4 ± 8.4d	152.3 ± 9.24c	131.1 ± 5.37b	46.26 ± 1.62b	44.75 ± 1.12b
	2F	271.0 ± 21.3d	137.9 ± 13.82bc	133.2 ± 10.65bc	52.82 ± 2.64c	48.57 ± 1.21c
	3F	268.5 ± 36.2cde	126.3 ± 7.02b	142.2 ± 7.25c	49.23 ± 1.97bc	49.07 ± 1.23c
	4F	201.1 ± 22.2b	57.0 ± 4.12a	144.0 ± 4.47c	71.64 ± 3.58e	55.90 ± 1.40d
	5F	169.9 ± 2.0a	55.2 ± 13.68a	114.7 ± 2.29a	67.52 ± 3.38de	63.09 ± 1.58e
	6F	180.5 ± 25.6ab	50.1 ± 11.25a	130.5 ± 3.67b	72.26 ± 2.53e	69.04 ± 1.73f
	3S	196.9 ± 23.0b	56.6 ± 10.61a	140.4 ± 7.16cb	71.27 ± 3.56e	57.74 ± 1.44d
	4S	213.3 ± 30.1bc	68.9 ± 7.23a	144.4 ± 5.92c	67.68 ± 2.71ed	58.54 ± 1.46d
	5S	193.7 ± 14.1b	71.3 ± 16.34a	122.4 ± 7.35ab	63.21 ± 3.16d	83.18 ± 2.08g
Mung bean	Seeds	310.1 ± 8.9e	151.9 ± 14.23d	158.1 ± 8.06e	51.00 ± 2.55a	32.68 ± 0.82a
	1F	244.3 ± 1.5d	104.7 ± 9.46bc	139.5 ± 5.72d	57.13 ± 2.00bc	37.33 ± 0.93b
	2F	236.2 ± 1.1c	102.2 ± 9.21bc	144.0 ± 11.52de	60.98 ± 3.05c	42.48 ± 1.06c
	3F	230.3 ± 1.1bc	110.4 ± 3.27bc	119.9 ± 6.12bc	55.90 ± 2.24ab	46.03 ± 1.15d
	4F	221.9 ± 5.1b	83.0 ± 1.43a	138.9 ± 4.30d	62.60 ± 3.13c	53.81 ± 1.35e
	5F	210.9 ± 15.7ab	81.5 ± 2.46a	129.4 ± 2.59c	61.37 ± 3.07c	61.75 ± 1.54f
	6F	192.4 ± 4.1a	79.9 ± 0.89a	112.5 ± 3.16ab	58.47 ± 2.05c	76.73 ± 1.92g
	3S	229.1 ± 14.8bcd	91.5 ± 5.47b	137.5 ± 7.01d	60.04 ± 3.00c	52.77 ± 1.32e
	4S	222.4 ± 2.8b	78.4 ± 14.06ab	144.0 ± 5.90d	49.92 ± 2.00a	60.54 ± 1.51f
	5S	174.2 ± 26.0a	70.0 ± 7.14a	104.2 ± 6.25a	59.82 ± 2.99c	89.87 ± 2.25h

Values, within the selected characteristic, designated by the different letters are significantly different ($P < 0.05$).
1F–6F – 1–6-day-old fresh sprouts; 3S–5S – 3–5-day-old stored sprouts.

Source: Swieca et al., Food Chem., v. 185, p. 99-105, 2015.

Sprouted beans

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1F–6F – 1–6-day-old fresh sprouts; 3S–5S – 3–5-day-old stored sprouts.

Source: Swieca et al., Food Chem., v. 185, p. 99-105, 2015.

Sprouted beans

Problem 1: PPO activy intensify the darkening of fresh sprouted beans.

Table 1
Impact of various inhibitors on the PPO activity in mung bean sprouts.

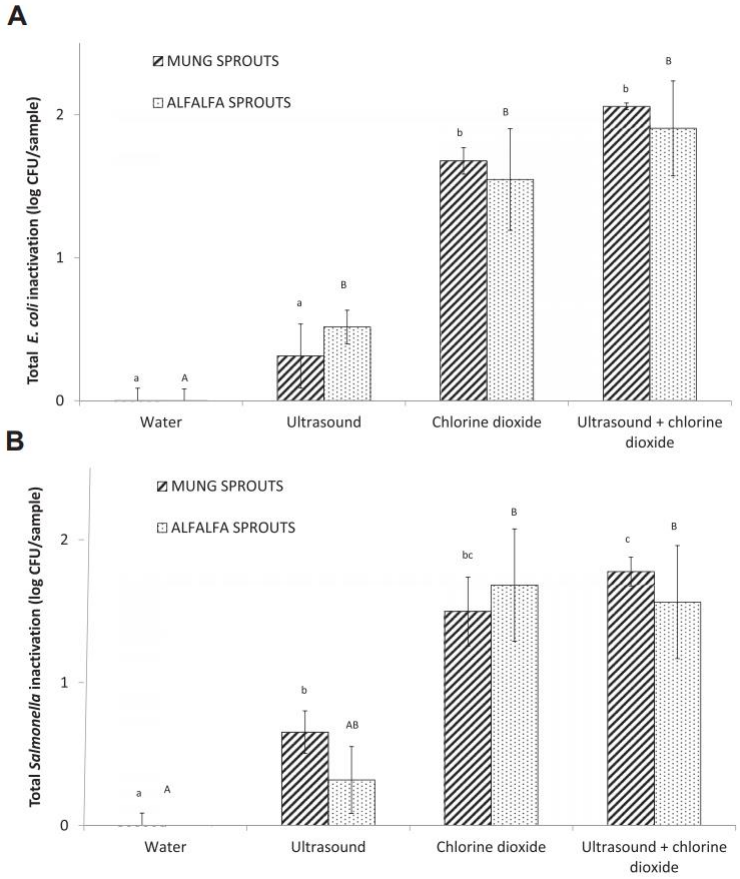
	Inhibitor concentration [mM]	Relative activity [%]
Control	–	100.00 ± 0.85g
Citric acid	0.2	93.24 ± 6.48f
	2	77.76 ± 9.00e
	20	47.18 ± 5.29d
Ascorbic acid	0.2	16.60 ± 2.12c
	2	8.76 ± 0.85bc
	20	2.61 ± 1.16a
L-cysteine	0.2	9.51 ± 0.79c
	2	6.15 ± 2.37b
	20	0.91 ± 0.30a

Means (±SD) with different letter are significantly different ($n = 9$; $\alpha = 0.05$).

Source: Sikora and Swieca et al., Food Chem., v. 329, p. 1160-1166, 2018.

Sprouted beans

Problem 2: Sprouts have been classified as a source of food-borne illness such as *Salmonella* and *E. Colli* O157. This has led to the application of antimicrobial processing technologies.



Source: [Sikora and Swieca et al., Food Chem., v. 329, p. 1160-1166, 2018.]

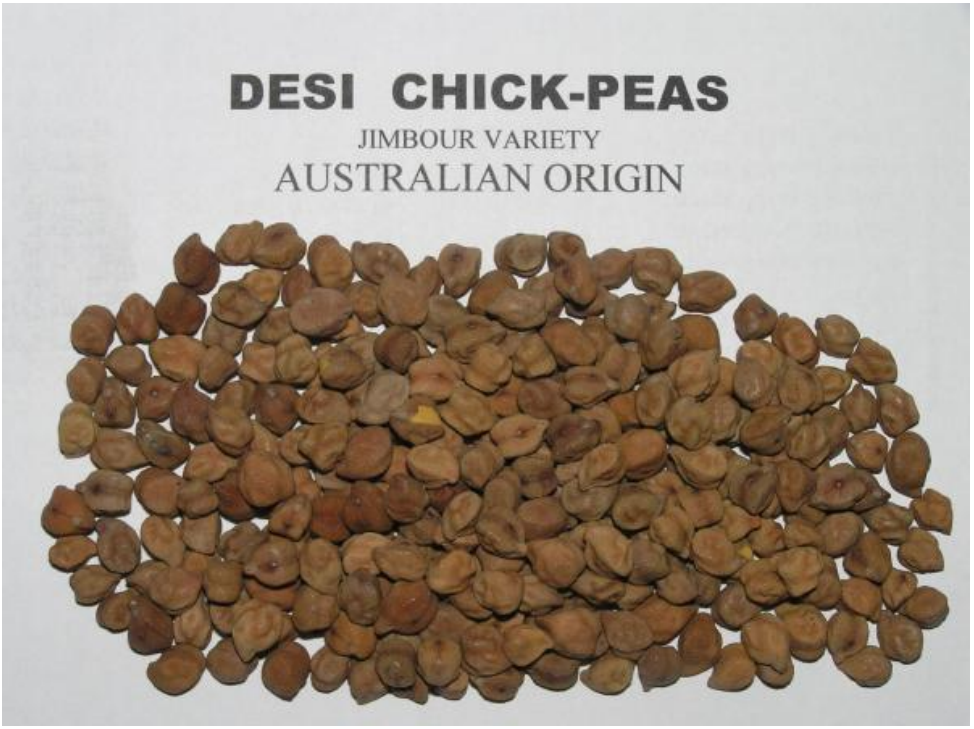
Fermented pulses

Mapo Tofu

Fermented pulses

What are the main reasons for performing pulses fermentation?

Fermented pulses



Fermented pulses

Common Indian fermented foods:

Wadi – done with Desi Chickpea

Soaking 6-12 h

↓

Ground to form a dough

↓

Mixing with spices

↓

Room temp. (20-27 °C) for 1-3 days

↓

Molded into balls

Smeared with oil

↓

Sun-dried for 4-8 days

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Fermented pulses

Common Indian fermented foods:

Dhokla

Blend of soaked rice and chickpeas

↓

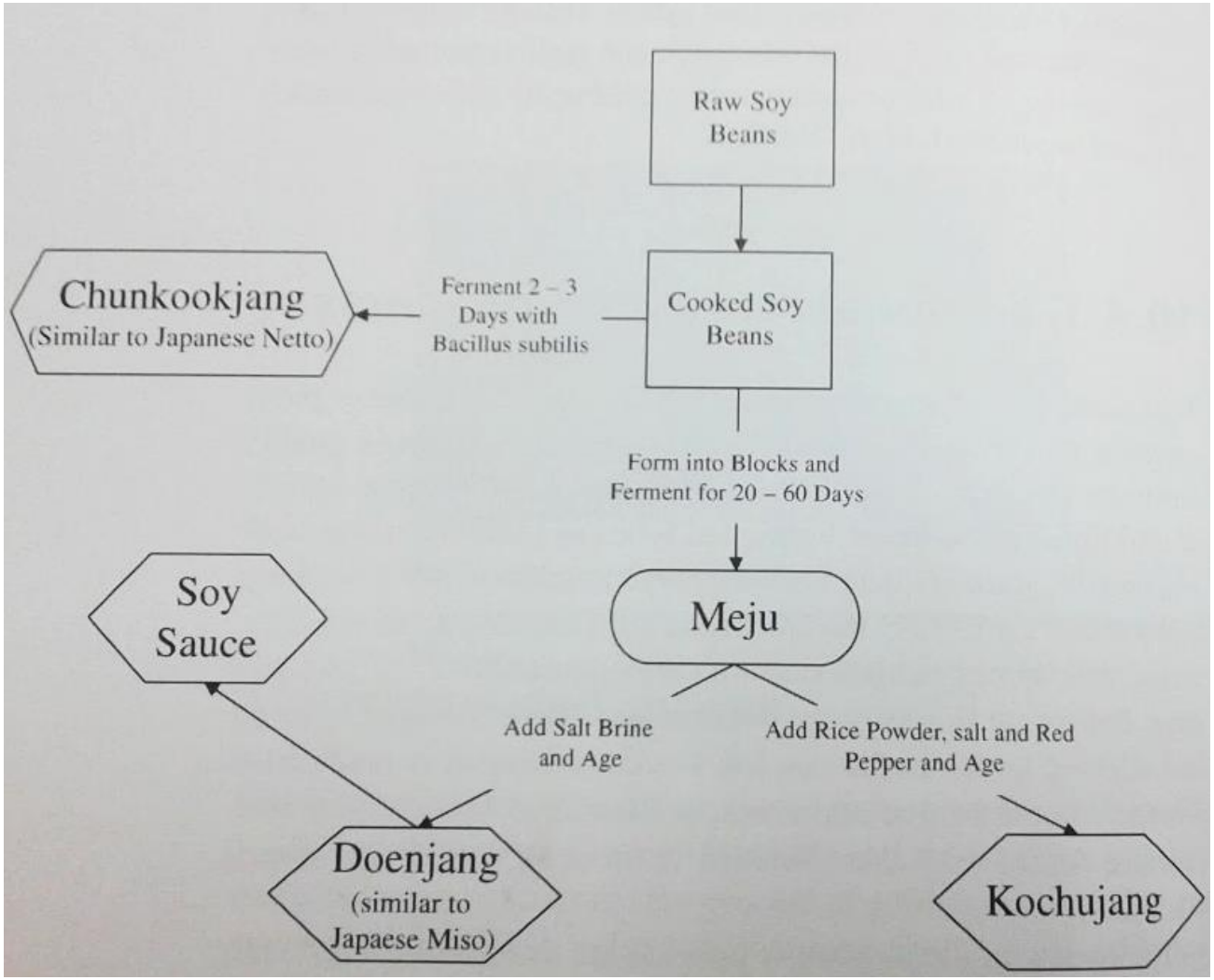
Room temp. for 12-15 h

↓

Steamed in an open cooker for 10 min

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

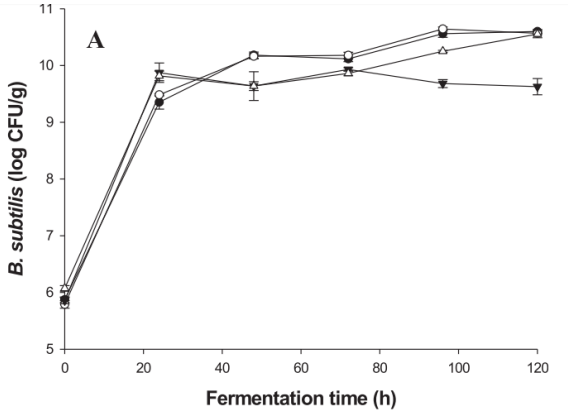
Fermented pulses - soybean products



Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Fermented pulses

Use of *B. subtilis* and *L. bulgaricus* concentration improve the red bean content of antioxidant substances, including total phenolics, anthocyanin, flavonoids and vitamins C and E.



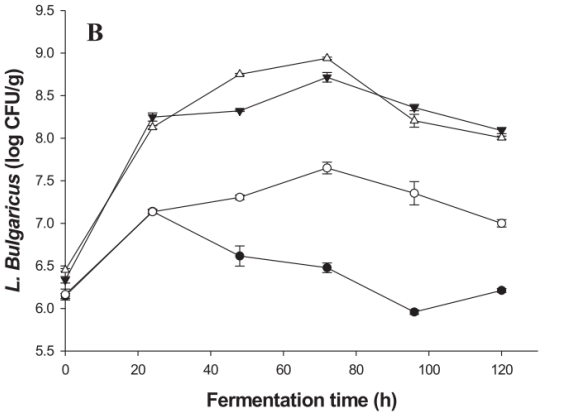


Table 4
Approximate composition and vitamins and γ-aminobutyric acid (GABA) contents of unfermented red beans and red beans fermented under optimal conditions.

	Unfermented red beans	Optimum fermented red beans
Crude fiber (%)	4.34 ± 0.18	4.85 ± 0.22*
Crude lipid (%)	1.12 ± 0.05*	0.17 ± 0.22
Crude protein (%)	22.68 ± 0.33	24.27 ± 0.41*
Crude ash (%)	0.78 ± 0.05	0.79 ± 0.03
Carbohydrate (%)	12.82 ± 0.2*	6.65 ± 0.21
Vitamin B12 (mg g^{-1})	ND	ND
Vitamin C (mg g^{-1})	5.41 ± 0.12	192.12 ± 0.09*
Vitamin E (mg g^{-1})	0.08 ± 0.06	0.38 ± 0.16*
γ-Aminobutyric acid (GABA)	ND	ND

ND: not detected.
Data are the mean ± SD (three independent experiments).
*Significantly higher than the other group. One-way ANOVA, Student's t test, $p > 0.05$.

Table 5
Antioxidant content and antioxidant activities of different extracts from unfermented red beans and red beans fermented under optimum conditions.

	Unfermented red beans			Optimum fermented red beans		
	Water	50% Ethanol	1% HCl/methanol	Water	50% Ethanol	1% HCl/methanol
Total phenols (mg gallic acid/g sample)	2.30 ± 0.02^{d}	2.59 ± 0.01^{d}	ND	3.25 ± 0.04^{b}	3.63 ± 0.03^{a}	ND
Total anthocyanins (μmol/g sample)	ND	ND	0.03 ± 0.06^{b}	ND	ND	0.04 ± 0.01^{a}
Total flavonoids (mg rutin/g sample)	ND	2.40 ± 0.02^{b}	ND	ND	2.64 ± 0.07^{a}	ND
IC_{50} of DPPH scavenging ability (mg mL^{-1})	84.55 ± 0.75^{d}	56.00 ± 2.99^{c}	ND	22.43 ± 0.97^{b}	16.64 ± 0.08^{a}	ND
Reducing power (A700 at 0.06 g mL^{-1})	0.65 ± 0.00^{c}	0.69 ± 0.02^{c}	0.46 ± 0.02^{d}	2.66 ± 0.08^{b}	3.00 ± 0.00^{a}	ND
IC_{50} of Fe^{2+} chelating ability (mg mL^{-1})	ND	ND	ND	>1000	75.32 ± 27.72	ND

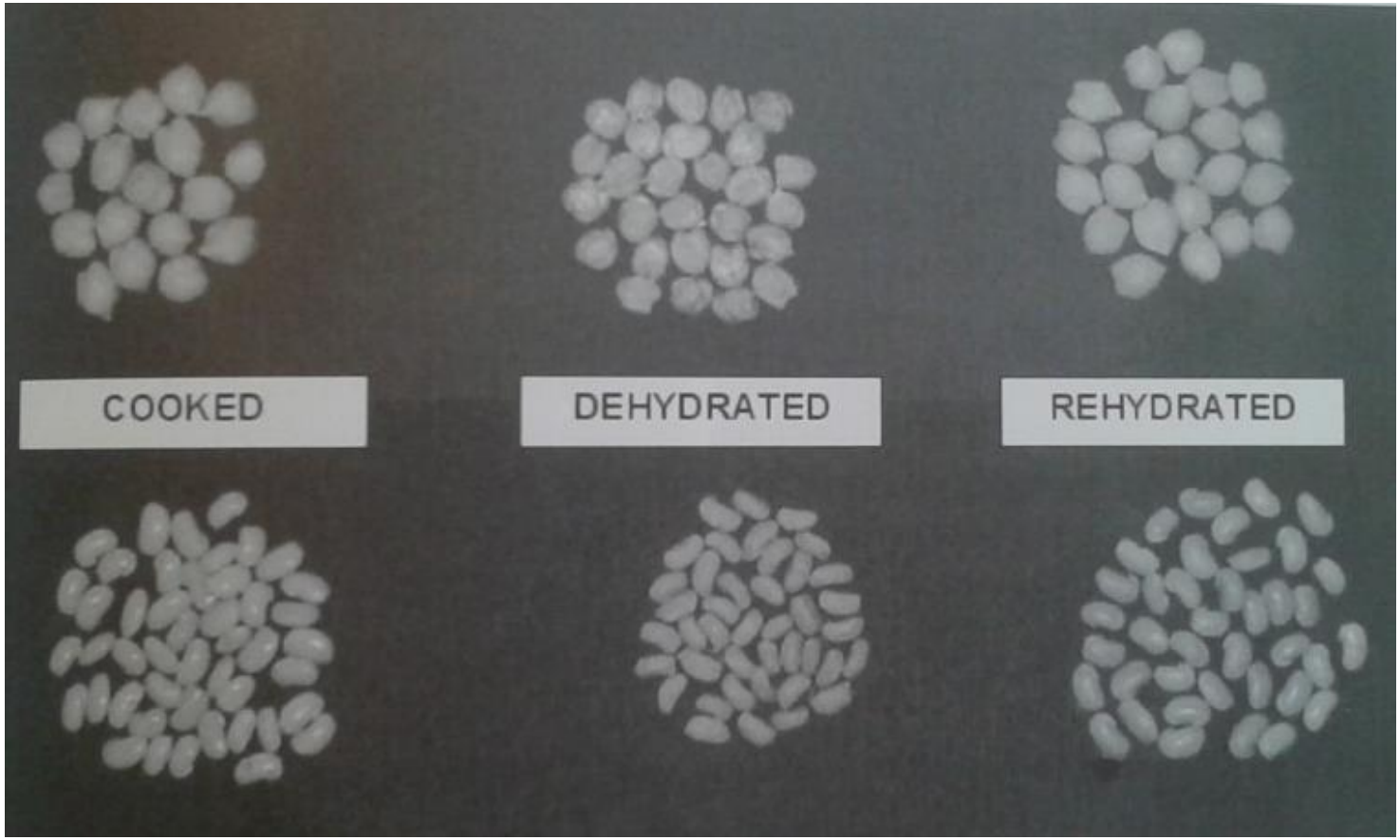
ND: not detected. Each value is the mean ± SD (three independent experiments).
$^{a-d}$Means in the same row followed by different letters are significantly different. One-way ANOVA, Duncan's multiple range test, $p > 0.05$.

Source: Jhan et al.,LWT, v. 63, p. 1281-1287, 2015.

Quick-cook dehydrated pulses

Chickpea

Soybean



Cooked, dehydrated (by combination of microwave power at 200 W) and convective hot-air at 160 °C for 13 min) and rehydrated (by immersion in boiling water for 15 min).

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

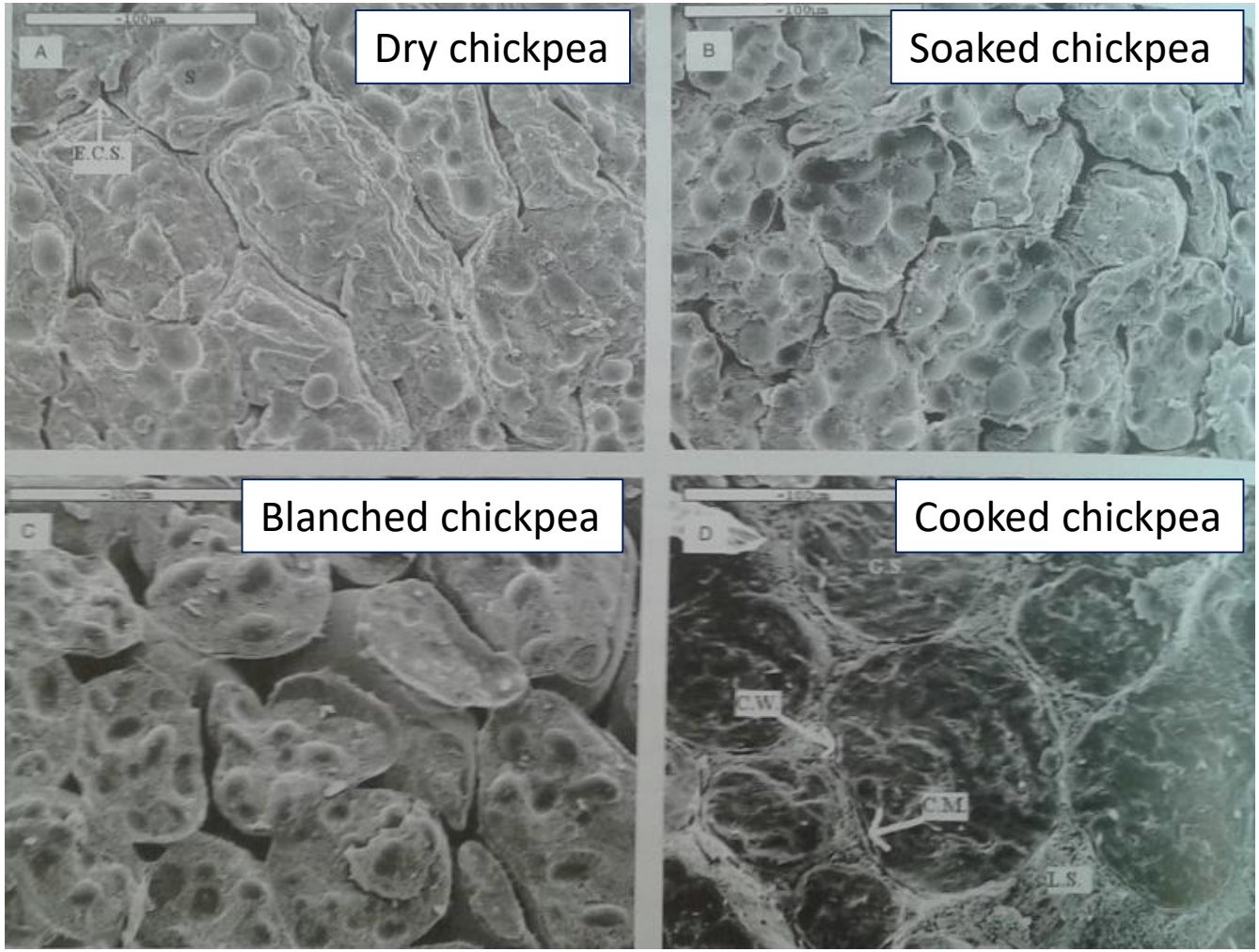
Quick-cook dehydrated pulses

Dehydration darkens the grains. Nonetheless, the appearance of rehydrated samples is quite similar to cooked ones.

Why?

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

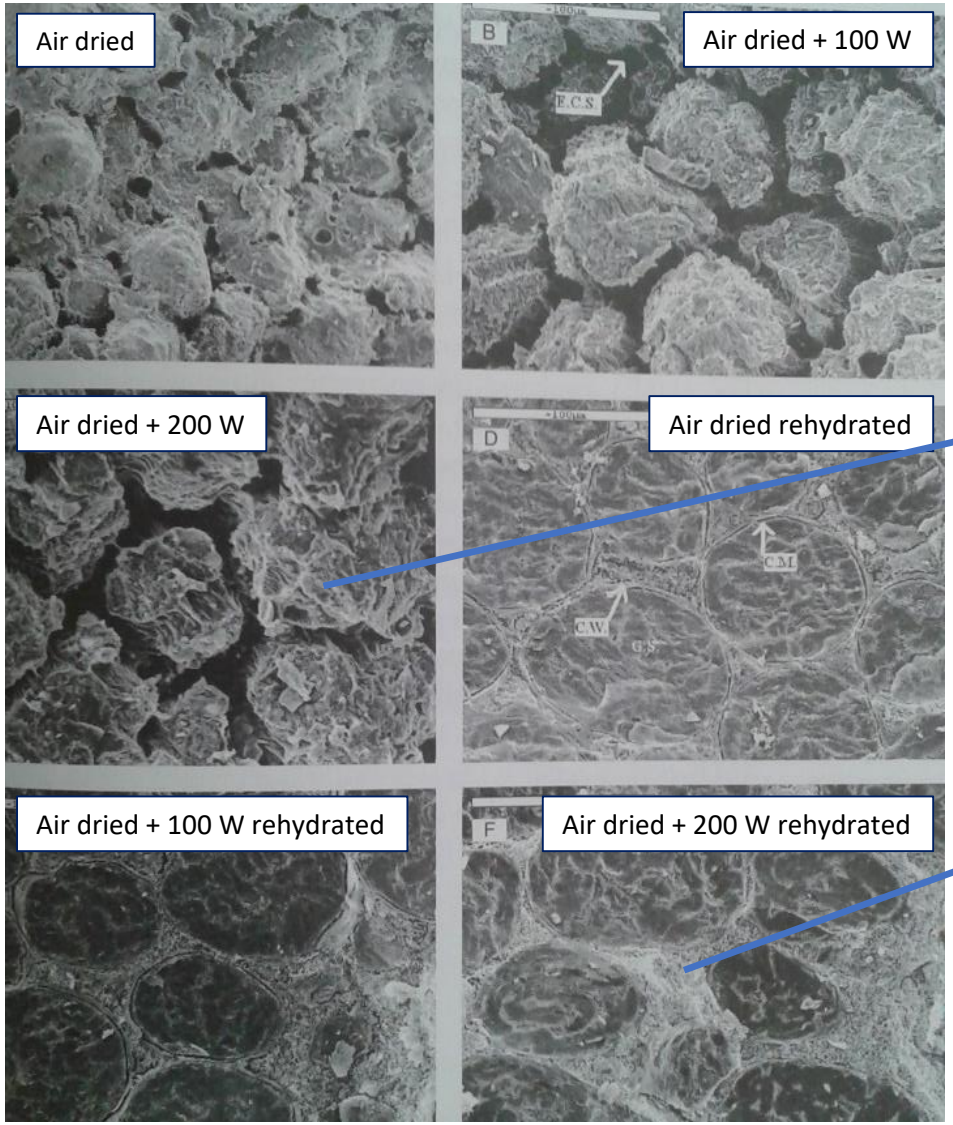
Quick-cook dehydrated pulses



CryoSEM images.

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Quick-cook dehydrated pulses



CryoSEM images.

Greater damage on starch granules

Larger extracelular spaces and cell sizes

Apparent cell wall damage

Hypothesis: internal forcel exerted on the cell during vaporization of the water at 200 W

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Pulse roasting

Pulse roasting

The central idea is...

Swell, Soften, Roasting → Crisp

↓

Add coating

↓

Product development

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Pulse roasting

The compact structure of raw chickpea subjected to roasting may cause an increase in the vapor pressure of water, so the steam that is generated causes the chickpeas to expand during roasting.

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Pulse roasting

Chickpea

↓

Cleaning and grading

↓

Soaking **1 hour in salt solution, 20% NaCl**

↓

Draining

↓

Roasting **4-5 min, ~140 °C**

↓

Girit Leblebi

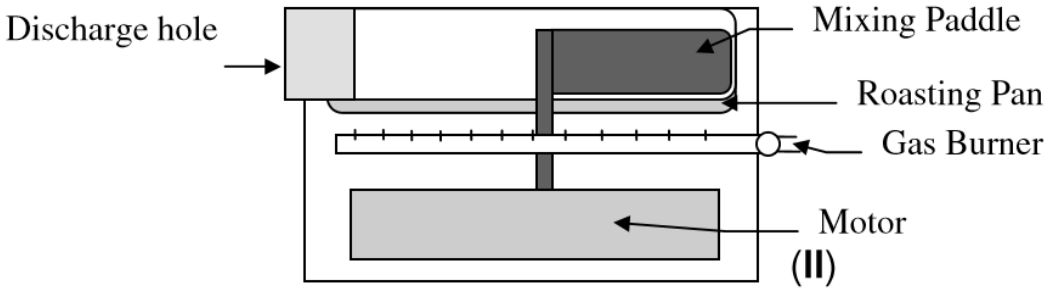


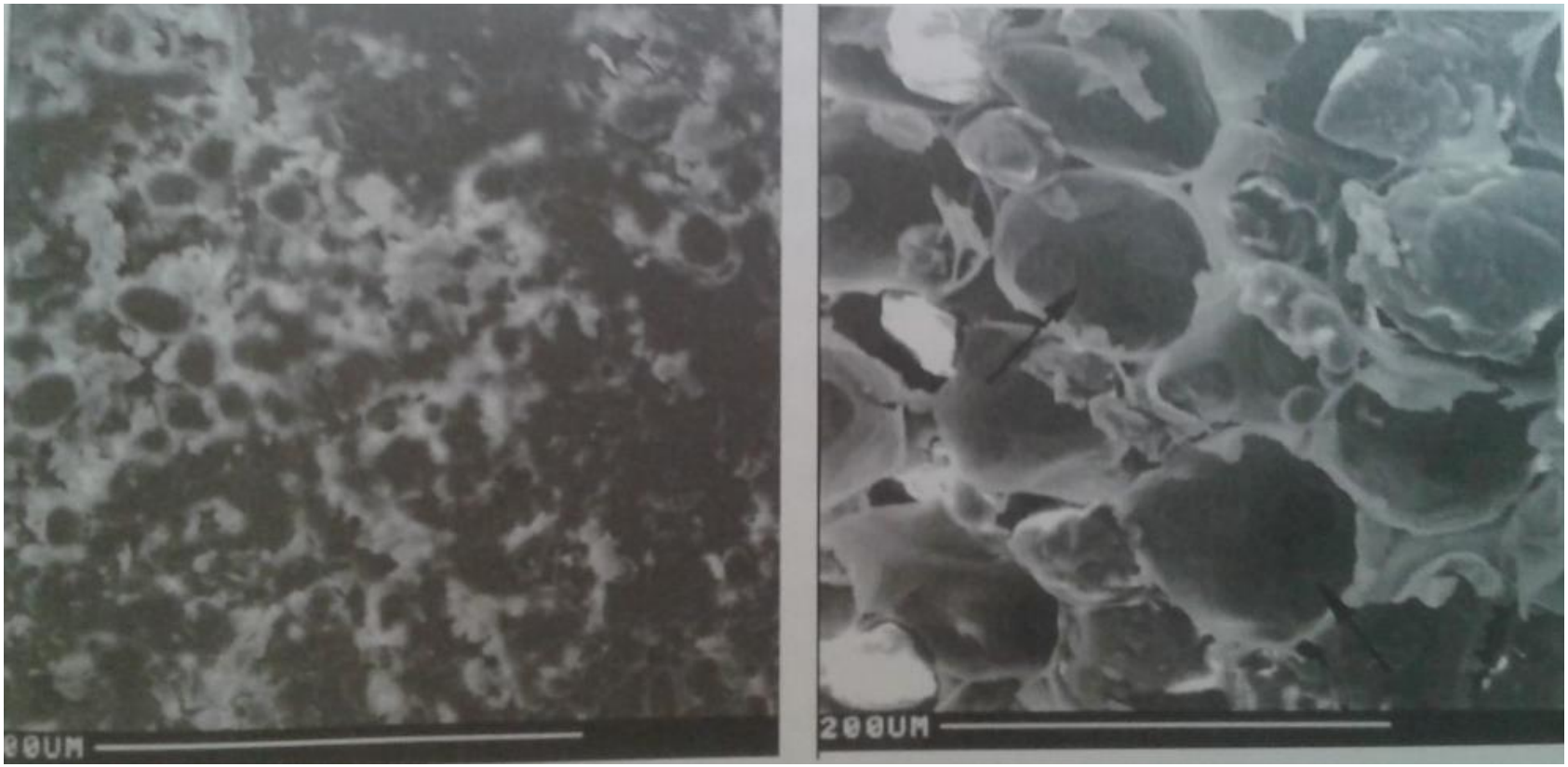
Figure 3. Chickpea roaster and speckler; (I): head view, (II) front view.

Source: Coskuner and Karababa, Food. Rev. Int., v. 20, p. 257-274, 2004.

Pulse roasting

Tighly packed structure

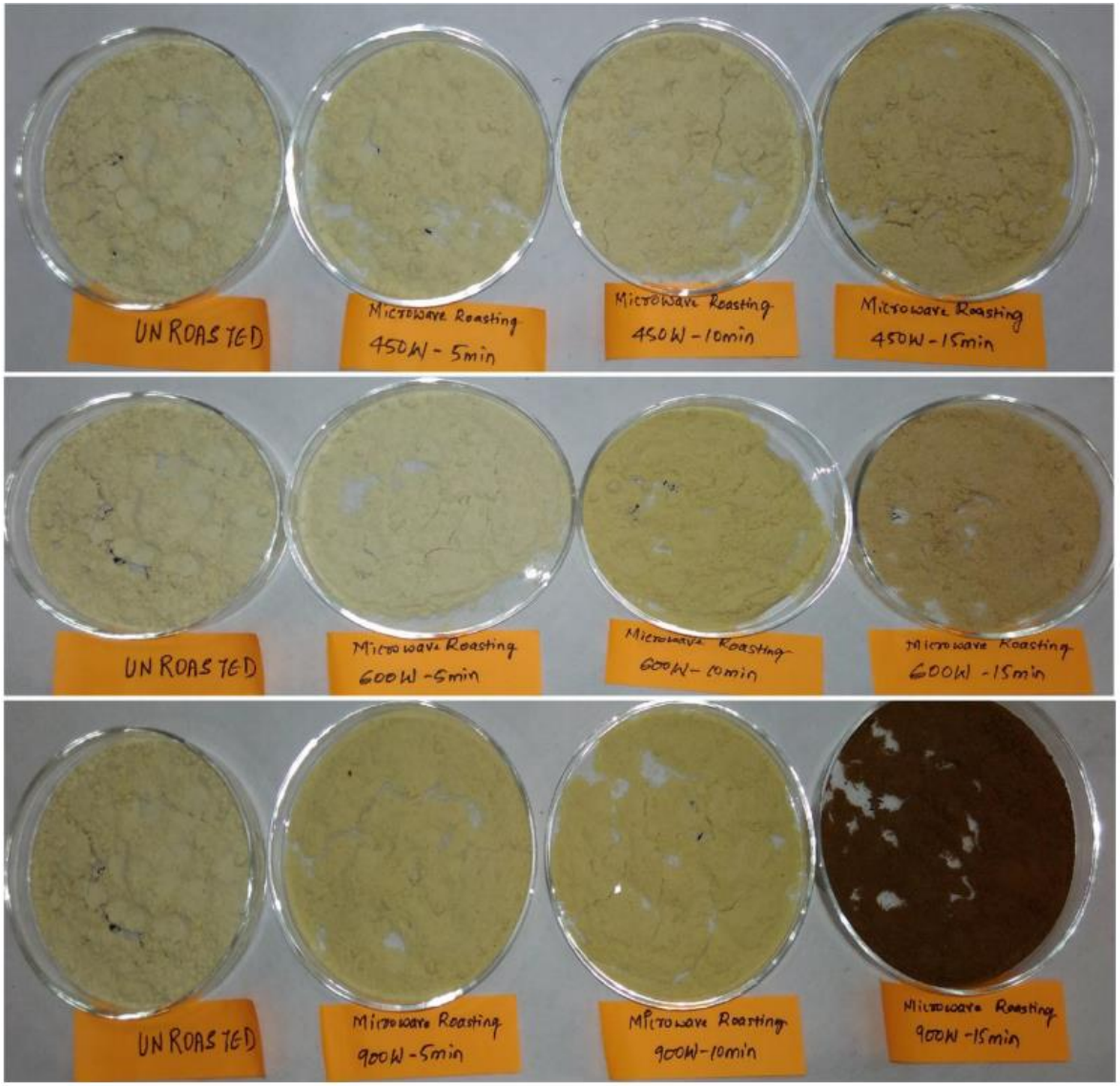
Air spaces in the cotyledon



SEM of raw and roasted chickpea.

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Pulse roasting



Color variation of chickpea powder at different time and power combination.

Source: Jogihalli et al., LWT, v. 79, p. 223-233, 2017.

Pulse roasting

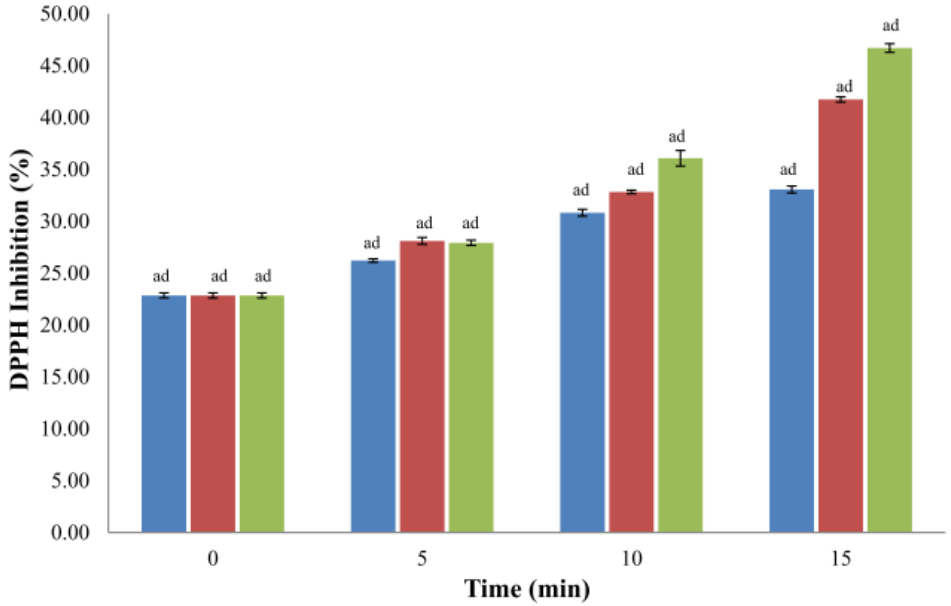


Fig. 5. Effect of microwave roasting on the antioxidant activity of chickpea. The superscripts 'a' and 'c' denotes significant effect of time and power respectively (roasting parameters) on measured property at $p < 0.05$ while the superscripts 'b' and 'd' respectively highlights non-significant impact of roasting time and power at $p < 0.05$. (Legend- ■ 450 W, ■ 600 W, ■ 900 W).

Source: Jogihalli et al., LWT, v. 79, p. 223-233, 2017.

Pulse roasting

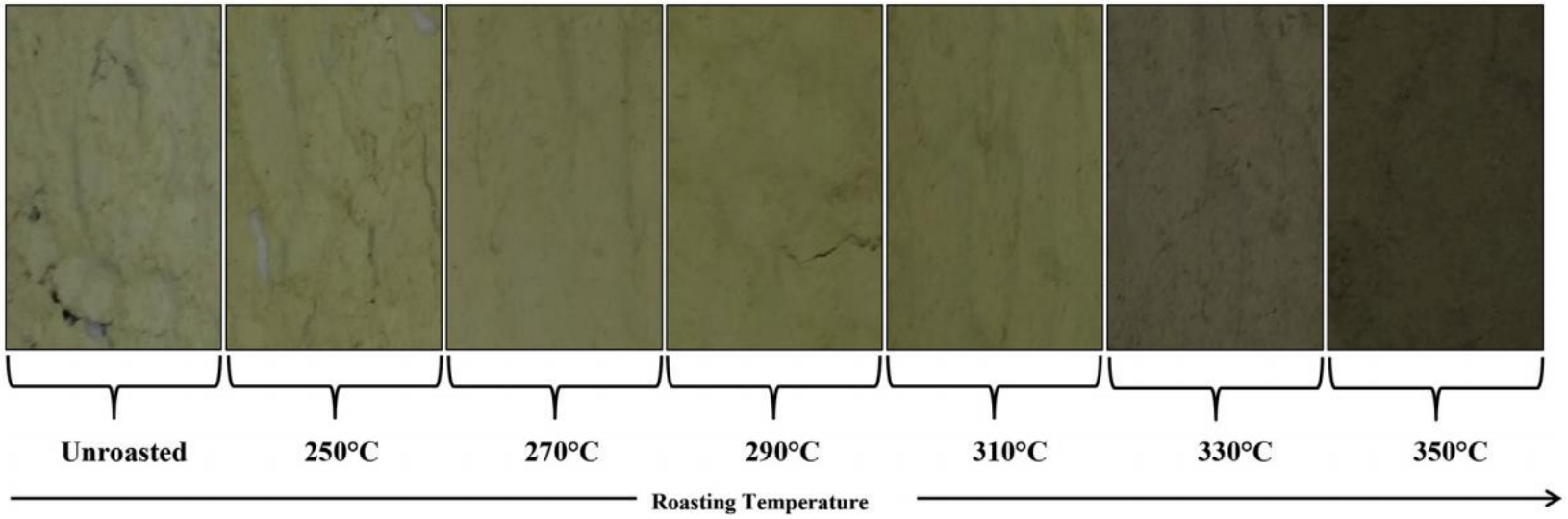


Fig. 1. Effect of hybrid roasting on color of chickpea. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Source: Jogihalli et al., LWT, v. 86, p. 456-464, 2017.

Pulse roasting

Chickpea

↓

Cleaning and grading

↓

First tempering

Preheating: 5-8 min at 100 °C or 10-20 min at 70-80 °C
Resting: 12-18 h or 2 days in sack and 2-10 days on the wood or concrete surface

↓

Second tempering

Preheating: 5-8 min at 100 °C or 10-20 min at 70-80 °C
Resting: 12-18 h or 2 days in sack and 2-10 days on the wood or concrete surface

↓

Third tempering

Preheating: 5 min at 70-80 °C
Resting: 12-18 h in sack and 20-45 days on the wood or concrete surface

↓

Moistening

↓ **10-13%**

Resting

↓

Grading

↓

First roasting

Preheating: 1-2 min at 50-60 °C
Roasting: 6-7 min at 100-150 °C

↓

Second roasting or Speckling

↓ **3-4 min at 100-130 °C**

Dehulled roasted chickpea

Sari Leblebi

Source: Tiwari et al., Pulse Foods, Chapter 10, 2011, 475p.

Article to be studied for the next class:

Linsberger-Martin et al. (2013). High hydrostatic pressure influences antinutritional factors and in vitro protein digestibility of split peas and whole white beans. LWT – Food Sci. and Tech., v. 51, p. 331-336.