

# How can we enhance human health by improving the nutritional value of rice?

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Fiber

Vitamins

Minerals

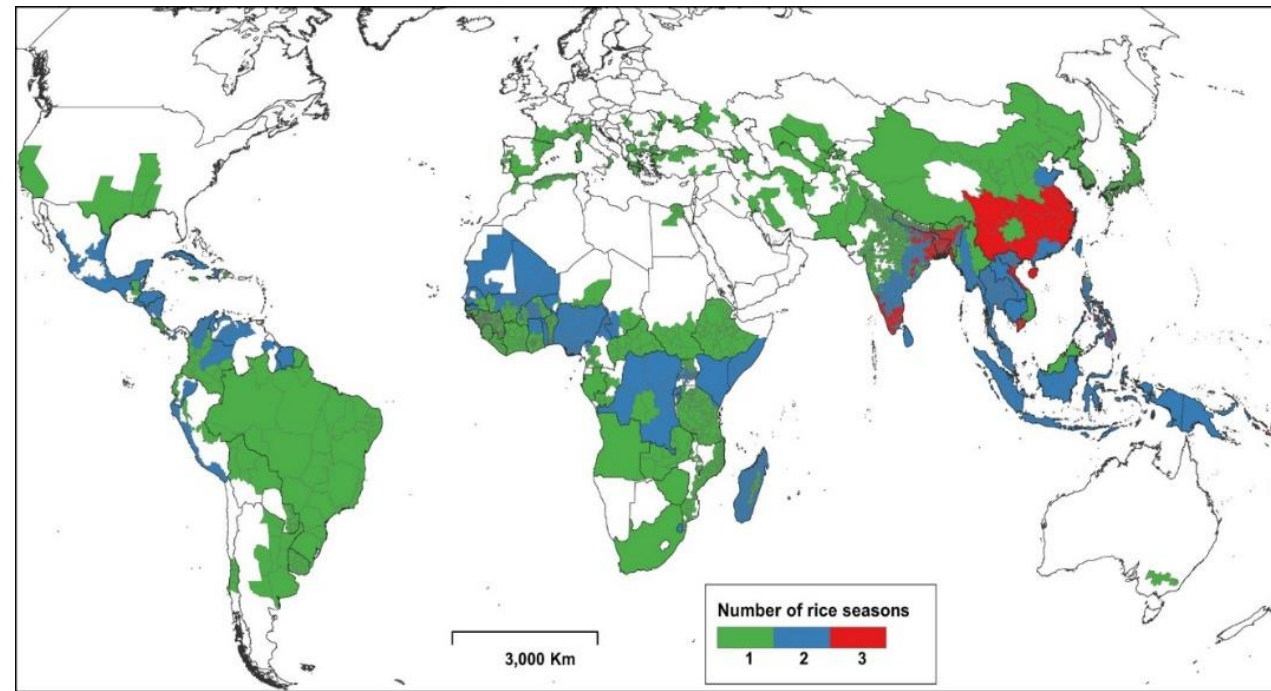
Protein

Phytic Acid – reduce it

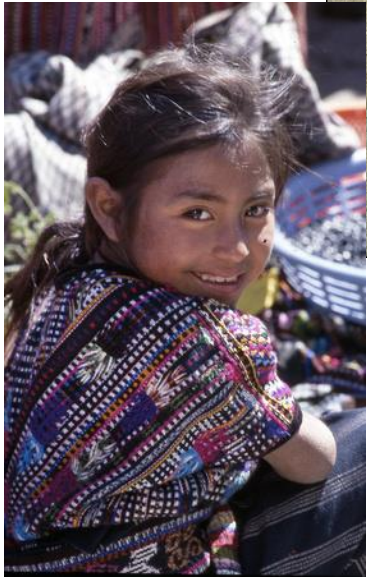
Antioxidants

# Why Rice?

- Staple food for > half the world's population
- Critical to food security in many low-income countries throughout Asia, Africa & Latin America



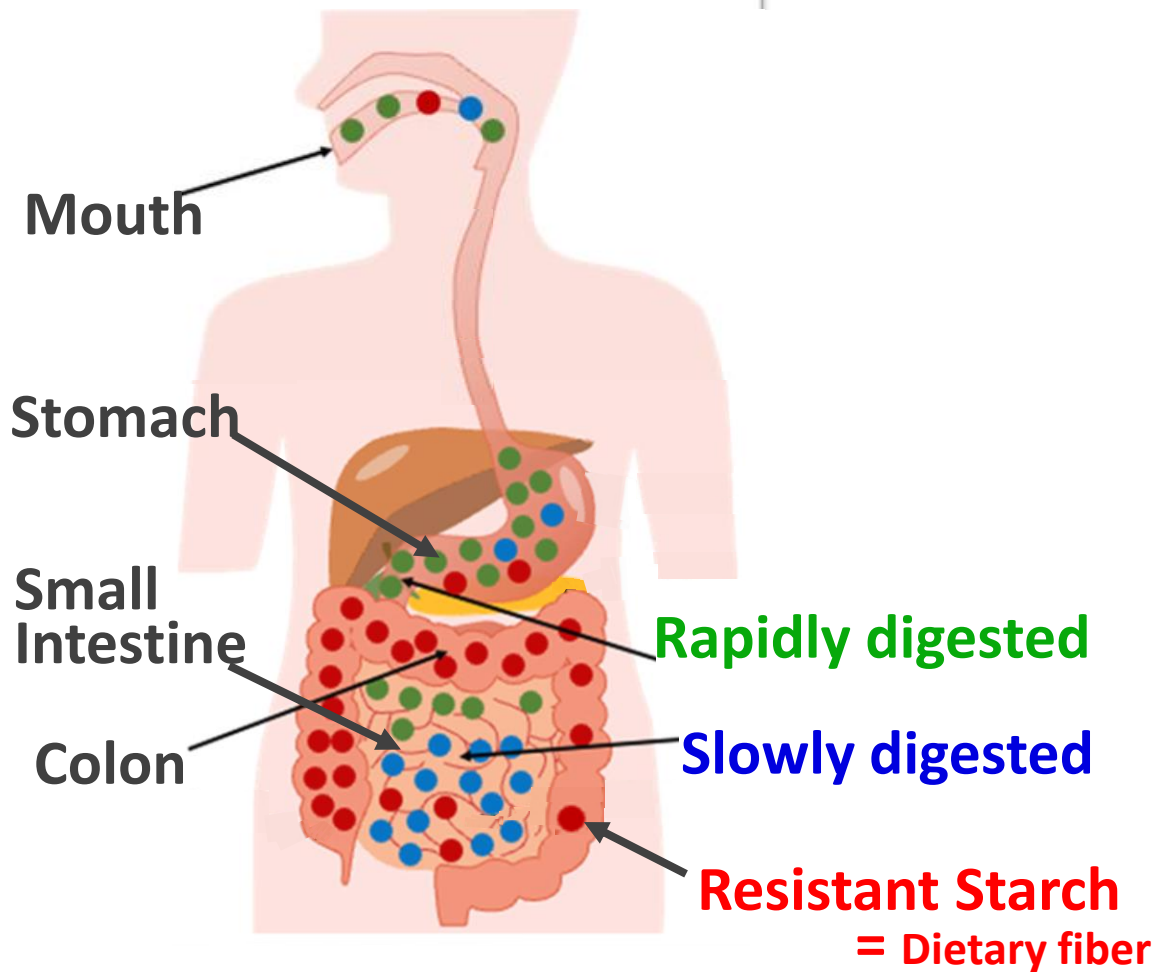
<https://doi.org/10.1038/sdata.2017.74>



Credit: STR/AFP/Getty

# RESISTANT STARCH (RS): 0 calories, GI = 0, & is dietary fiber

RS resists digestion in the healthy human stomach + small intestine



## Blood glucose

mmol/L

10

8

6

4

0

1 hr

2 hr

3 hr

4 hr

5 hr

Milled white rice - *est* GI 73

Brown rice

Hi-RS rice - *est* GI 53  
(*sbe3*, 5-8X RS)

RS and *est*GI from Pinson unpublished

# Types & Forms of Rice Marketed:

## Long grain Rice = “dry & fluffy”

Amylose: 20-24% (intermed.)  
≈ 75% US consumption, 2022



## Medium/Short grain

“sticky rice”, Asian rice  
Amylose: Low, 11-19%  
≈ 25% US consumption, 2022



## Brown Rice = whole grain

Firmer, dryer texture  
7X fiber! & > minerals, vitamins,  
fats, & protein  
Rancidity & long cooking time  
≈ 3% US consumption, 2022



## Parboiled, “converted”

Pre-steamed then milled  
Firm, separated cooked kernels  
> minerals & vitamins, slight > fiber  
Traditional in S. Asia & W. Africa  
≈ 57% US consumption, 2022

# Parboiling reduces breakage during milling



Milling rice by pounding  
In mortar & pestle

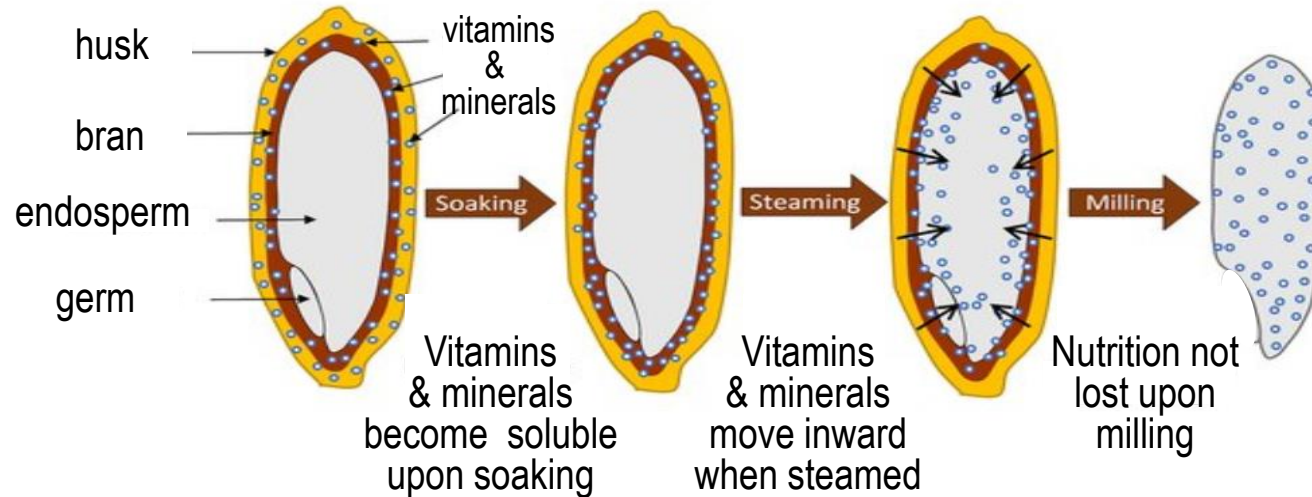


**Parboiling:** soak, steam, & dry before milling the rice



Photos: [https://www.facebook.com/photo.php?fbid=444164469737174&id=372463356907286&set=a.374818566671765&locale=ru\\_RU](https://www.facebook.com/photo.php?fbid=444164469737174&id=372463356907286&set=a.374818566671765&locale=ru_RU); [newrathnarice.com/technology.html](http://newrathnarice.com/technology.html)

# Parboiling retains minerals & vitamins



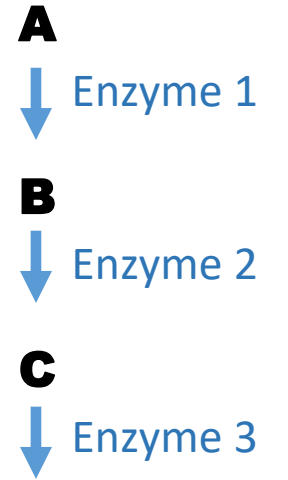
## Contributed to the 1926 Discovery of Thiamine (Vit. B1)

- **Beriberi**, deadly neurological disease, became epidemic in the Dutch East Indies (Indonesia) in the 1850's
- A Dutch military Dr. (Dr. Eijkman), presuming microbial disease, injected microbes isolated from beriberi victims into chickens
- Control group exhibited leg paralysis from beriberi just as fast as the injected chickens.
- Rep. 2: all chickens again developed leg paralysis, but then all recovered!
- Were fed cooked white rice leftover from the hospital, when ran out, switched to uncooked brown rice
- Further study ruled out microbes in cooked rice
- 2<sup>nd</sup> Dutch military Dr. (Dr. Grinjs) realized beriberi NOT common in Dutch colonies in W. Africa, where milled parboiled rice is the staple
- **Thiamine (Vitamin B1)** was discovered by team of Dutch scientists in **1926**

# Nutrition in 1/2-cup cooked rice (1 US serving)

		White	Parboil	Brown	
Energy	kCal	112	114	116	
	%DV 2000	6	6	6	
Vitamins %DV	A ← β-carotene	0	0	0	HarvestPlus, GMO Daffodil + bacterial genes
	B1, Thiamine	2	6	14	
	B2, Riboflavin	1	2	2	
	B3, Niacin	3	9	13	
	B5	6	6	7	
	B6	3	8	9	
	B7	6	9	12	
	B9, Folate	1	1	2	
	B12	0	0	0	Meats, dairy, eggs
	C	0	0	0	Fruits

## Golden Rice, GMO



## β-Carotene

GMO rice approved in the Philippines 2021

EU now allows Gene Editing ≤ 20 DNA bases

Data compiled from: food package labels, [nutrivore.com](http://nutrivore.com), [www.nutritionvalue.org](http://www.nutritionvalue.org), [www.healthline.com](http://www.healthline.com)

# Nutrition in 1/2-cup cooked rice (1 US serving)

		White	Parboil	Brown	
<b>Energy</b>	%DV 2000	6	6	6	
<b>Protein</b>	DV = 50g	<b>5</b>	<b>5</b>	6	1.5X proprietary mutant, low in lysine
<b>Fiber</b>	DV = 28g	<b>1</b>	<b>2</b>	7	High Amylose (2x) Public <i>sbe3</i> gene (7-8X)
<b>Minerals</b>	Copper	8	10	10	
	Manganese	15	16	38	
	Selenium	9	10	10	
	Iron	<b>1</b>	<b>1</b>	<b>2</b>	HarvestPlus (Gates \$)
	Zinc	<b>3</b>	<b>2</b>	6	HarvestPlus
	Calcium	<b>1</b>	<b>2</b>	7	
	Magnesium	<b>2</b>	<b>4</b>	9	} 3-4X with genes on chr 2 & 7 ( <i>Pinson unpublished</i> ) bioaccessibility?
	Phosphorus	<b>3</b>	6	8	
Potassium	<b>1</b>	<b>2</b>	<b>2</b>		

Data compiled from: food package labels, [nutrivore.com](http://nutrivore.com), [www.nutritionvalue.org](http://www.nutritionvalue.org), [www.healthline.com](http://www.healthline.com), [parishrice.com](http://parishrice.com)



# Phytic acid reduces protein & mineral bioaccessibility

- PA binds to proteins, Vitamin D, Ca, Fe, Zn, Mg, K, & Mn; reducing their absorption
- Ex: consuming 5-10 mg of PA reduces Fe absorption by 50%
- 10-25% of brown rice PA is retained after milling; 10-25 mg PA in ½-cup cooked milled rice  
*(Pinson unpublished)*
- PA especially concerning in diets low in meat and animal products (e.g., vegans, & impoverished)
- Double Damage in animal feed
  - reduces nutritional efficiency
  - > excess P in waste (e.g., triggers red algae blooms in the Gulf of Mexico)
  - feed in USA now supplemented with phytase to break down PA
- Soaking 4-12 hrs reduces PA by activating endogenous phytases; standard for dry beans
- **Low PA rice - public ARS-created mutant** *(Bryant et al. 2005, DOI: 10.1094 / CC-82-0517)*
  - PA reduced by 45% **AND** 5-10X > in free-P in endosperm
  - germination and seedling vigor not notably depressed

# Antioxidants in Color-bran Rice

- Reduce inflammation (diabetes) & cancer
- Novelty > “brown” rice consumption
- “Emperor rice” in Asia
- Inhibits amylase – slows starch digestion



	DPPH dry μg/100g (Pinson unpub)	Antioxidant activity ounce-for-ounce cooked rice vs fresh blueberries (wet wt)
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Standard brown rice	75	1/10
Red rice (tannins, <i>Rd</i> )	345	1/2
Purple rice (anthocyanins, <i>Pb</i> )	235	1/3
MNSN1 selections ( <i>Rd+Pb</i> )	720	<b>= blueberries!</b> (Pinson et al., unpublished)

Blueberry

1640

(Rodrigues et al. 2011 doi:10.1590/S0101-20612011000400013)

# How can we enhance human health by improving the nutritional value of rice?

**Fiber** – breed, Resistant Starch *sbe3* gene is publicly available

reduces <sub>est</sub>GI from 73 to 53, cooked rice is quite firm – acceptability concerns

**Vitamins** - Brown rice, Parboiling, Gene editing

**Minerals** - recently mapped P+Mg+K genes to chr 2&7, 3-4X increases

**Protein** - proprietary 1.5X mutant, still low in lysine; mutation breeding

**Phytic Acid reduction** - public (ARS) *lpa* mutation

**Antioxidants** - Red + Purple combined = even more antioxidants

- can increase acceptance of brown rice, & < GI