Acai: The World's Richest Antioxidant Source

Alexander Schauss, PhD

Protection from Oxidative Stress
in vitro and *in vivo* in Humans by an
Amazonian palm berry,
Euterpe oleracea ("açai")

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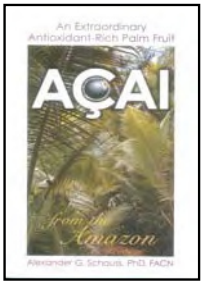
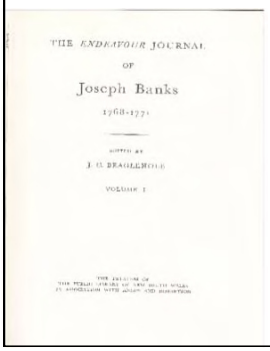


Açai grows primarily in the flood plains of the Amazon River and its tributaries, covering an area of over 12 million acres.

Up to 7,000 palms can grow per acre.

In the Amazon flood plains acai palm trees form a canopy that protect plants from equatorial solar radiation from the sun.

1768: Açai Fruit Reported by Joseph Banks, botanist on Captain James Cook's, *The Endeavour*.
1791: Acai Fruit documented by Portuguese explorers.


THE *ENDEAVOUR* JOURNAL
OF
Joseph Banks

2,400 Palm Species in the World.
Açai palm (*Euterpe oleracea*) one of 3 species of the Genus, *Euterpe* only found in the Amazon, especially in flood plains.

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Açai fruit grows on palm trees inflorescence.

Immature fruit on inflorescence.

Inflorescence with mature açai fruit ready for harvest

Açai palm can produce up to 1,000 kilos of acai fruit in a 7-10 year period.

Fruit is 2.5 cm, ~87% is seed, 13% pulp & skin

Açai palm inflorescence branches being removed 50 meters above ground to strip acai fruit into baskets.

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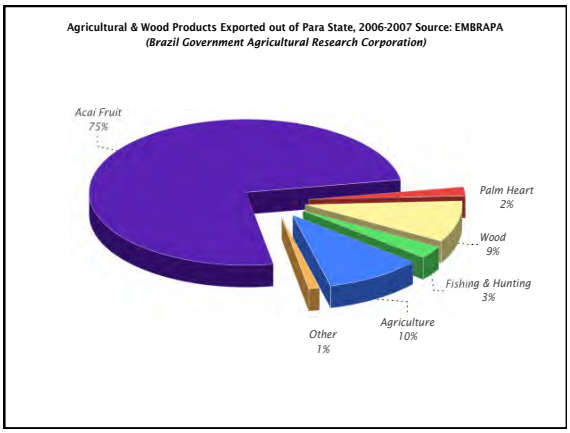
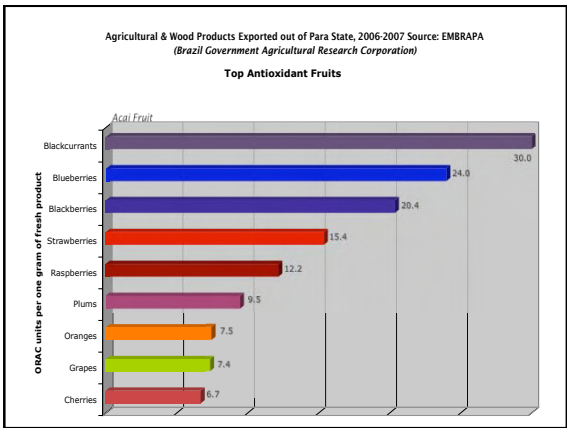
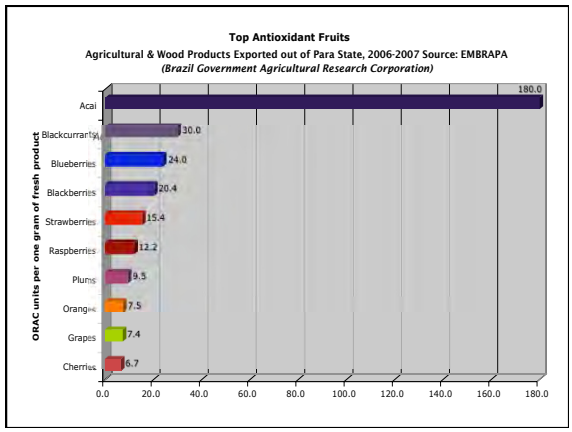


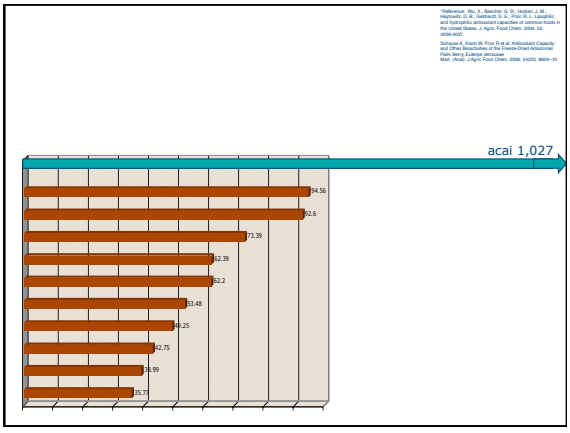
To Study Açai, it's Freeze-Dried

Vacuum freeze-drying preserves the:

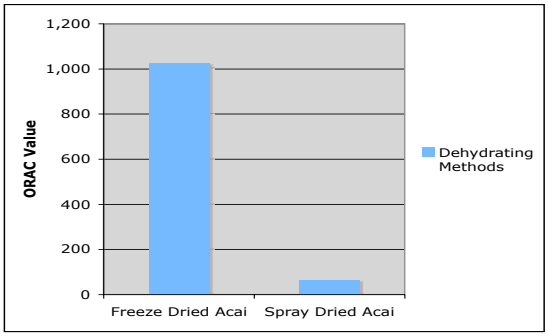
- **Phytochemical content**
- **Enzymatic activity**
- **Nutritional value**
- **Bioactivity of the fresh fruit**
- **Antioxidant activity**
- **Taste**
- **Shelf life of years**
- **Saves Energy (don't need to keep it frozen at -18° F)**







Freeze-Dried vs Spray Dried Açai



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Published Vitamin/Mineral Composition of Acai

Vitamins	Minerals
Vitamin A (Beta-carotene)	Calcium
Vitamin C	Magnesium
Vitamin E	Potassium
Vitamin D	Sodium
Vitamin B-1	Zinc
Vitamin B-2	Copper
Vitamin B-3	Iron
Vitamin B-6	Manganese
Vitamin B-12	Selenium
Pantothenic acid	Boron
Biotin	Chromium
Folic Acid	Molybdenum
Inositol	Iodine

Published Amino Acid Composition of Açai

Aspartic acid	Tyrosine
Threonine	Phenylalanine
Serine	Lysine
Glutamic acid	Histidine
Glycine	Arginine
Alanine	Proline
Valine	Hydroxyproline
Methionine	Cystine
Isoleucine	Tryptophan
Leucine	

Published Phytochemical Composition of Açai

*Primary anthocyanins:

- Cyanidin-3-glucoside
- Cyanidin-3-rutoside
- Cyanidin-3-diglycoside
- Cyanidin-3-glucoside-coumaraterutinoside
- Cyanidin-3-O-rutinoside

- Flavanols (numerous)
- Flavonoids (numerous)
- Flavonols (numerous)

Beta-sitosterol	Kaempferol
Campesterol	Luteolin
Catechin	Luteolin-4-glucoside
Chrysoeriol	Methyl-derivative of homoorientin
Coumeric acid	Myricetin
Deoxyhexose	Orientin
Epi-catechin	Proanthocyanin
Eriodictyol	Protocatchuric acid
Eriodictyol-7-glucoside	Protocatechic acid
Eurpatorin	Pterostilbene
Ferulic acid	Quercitin-3-arabinoside
Gallic acid	Resveratrol
Homoorietin	Sigmasterol
Isoquercitin	Taxifolin
Isovitexin	Vanillic acid

Published Nutritional, Lipid, and Fiber Composition of Açai

Fatty acids: 82% monounsaturated and polyunsaturated (palmitic, oleic, linoleic acids) - higher than virgin olive oil or avocado oil

Phytosterol content 1.25%

Very low in sodium (0.25%)

Very low in glucose/dissacharides (0.1 gram/100 grams)

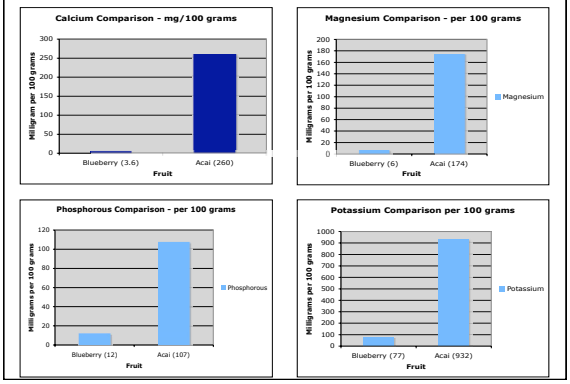
Low in carbohydrates (1.3 gram/100 grams)

High in soluble and water insoluble fibers.

Total Antioxidant Capacity (TAC) Per Serving (Hydrophilic-ORAC + Lipophilic-ORAC) Fruits and Berries, Adjusted % Moisture Content

Food	% Moisture Content	TAC *umol* TE/g	Serving Size (g)	TAC per Serving
Açai pulp	60.0	410.80	145	59,566
Blueberry (Cult)	85.0	62.20	145	9,019
Cranberry	87.1	94.56	95	8,983
Blackberry	86.9	53.48	145	7,701
Raspberry	85.8	49.25	123	6,058
Strawberry	91.1	35.77	166	5,938
Apples (Granny)	85.7	38.99	138	5,381
Avocado (Hass)	72.0	19.33	173	3,344

Nutrients Levels in Blueberries & Acai Pulp



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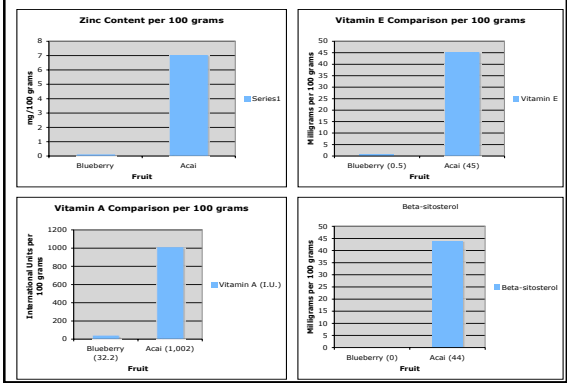

Published Antioxidant Assays of FD Açai

1) Total ORAC: 1,027 *u*mole TE/gram.
   Lipophilic ORAC highest of any fruit.
   Peroxyl radical scavenging capacity highest of any fruit or vegetable. A few spices are higher.

   TEAC and FRAP assay's confirm ORAC assay (744.0 *u*mole TE/gram; 249.0 *u*mole TE/gram.)

2) Superoxide ORAC (1,614 SOD units). Highest of any fruit or vegetable.

3) High hydroxyl and peroxynitrite scavenging activity (HORAC & NORAC assay)

4) Both a slow and fast antioxidant. TAO assay.

Human Pharmacokinetic Study of Açai Juice with Pulp and without Pulp

8 Differences between açai with pulp or without the pulp?

1. A large portion of antioxidants are bound to the fiber in the pulp.
2. Antioxidants in the fiber of the pulp are released in the gut and then absorbed.
3. Juice with pulp had ~45% more antioxidants (total anthocyanins) than juice if the pulp was removed.
4. Juice with pulp was significantly higher in plasma antioxidant levels.
5. Antioxidant compounds were consistently higher for 4 hours.

Clarified (pulp removed) vs Unclarified Açai Juice Study in Healthy Adults

6. Peak antioxidant levels in the blood dropped sooner if pulp is missing.
7. The maximum concentration of antioxidants was 105% higher if the pulp was retained.
8. Half-life of juice with pulp was 110% longer (6.6 hours) than without pulp (3 hours).

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Brain Health and Oxidative Stress

- The brain only weighs 2% of the body's weight, but it uses ~20% of the oxygen we breath.
- It is susceptible to oxidative stress.
- Does not possess the same antioxidant defenses used by the rest of the body.
- Is rich in fatty acids subject to oxidation.
- Is high in iron which can act as a catalyst, increases risk of lipid peroxidation.

Oxidative Stress a Risk Factor Against Brain Health

- Lipid peroxidation is associated with progressive damage to brain cells.
- To protect against oxidative damage, the brain releases two enzymes.
- Catalase converts hydrogen peroxide to harmless water and molecular oxygen.
- Superoxide dismutase (SOD) converts superoxide to oxygen and hydrogen peroxide (H_2O_2), which catalase turns H_2O_2 into H_2O and oxygen.

Açai Pulp Protects Against Oxidative Stress in the Brain

- A Brazilian study found evidence that the pulp in açai might protect the brain from free radical damage.
- The study pre-treated brain tissues of rats with açai.
- They exposed the tissues to hydrogen peroxide.
- The antioxidant polyphenols in acai significantly reduced the levels of lipid and protein damage caused by H_2O_2.
- Authors concluded that "açai could prevent the development of age-related neurodegenerative diseases."
- Clearly, more research is needed.

Evaluating Antioxidant Activity of Açai in Human Cells

1) Does açai support healthy immune function?
   Studied reactive oxygen species formation using polymorphonuclear cells (ROS PMN) assay
2) Does açai provoke cellular signaling between cells?
   Used cell-based antioxidant protection in erythrocyte (CAP-e) assay.

Antioxidant Protection of Human Erythrocytes Using the CAP-e Assay

1) Açai was able to significantly protect human cells from oxidative damage.
2) Reduce production of free radicals.
3) Reduce proinflammatory activity:
   a) fmlp ($p<0.001$)
   b) Leukotriene B4 ($p<0.05$)
   c) Interlukin-8 ($p<0.03$)


AGRICULTURAL AND FOOD CHEMISTRY

Comparison of Chemical and Cell-Based Antioxidant Methods for Evaluation of Foods and Natural Products: Generating Multifaceted Data by Parallel Testing Using Erythrocytes and Polymorphonuclear Cells

Study of a complex Açai/fruit juice drink

Questions:

1) Are the antioxidants in the juice absorbed after consumption?
2) Does it enter into circulation?
3) Does it enter into cells?
4) Does it protect human cells during oxidative stress?

Will 4 ounces a day of the juice enter human cells and protect adults from oxidative stress within 4 hours?

Will adults have less lipid peroxidation in their serum within 4 hours during a state of oxidative stress?

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Composition of Açai Fruit/Berry Juice

Unclarified, unfiltered, juice with water added only as needed to reconstitute powders, that contained no added extracts to superficially raise ORAC value, only whole fruit/berries including pulp concentrates.

Primary ingredient: Açai (*Euterpe oleracea*)
White grape (*Vitis* L.)
Nashi pear (*Pyrus pyrifolia*)
Acerola (*Malpihia glabra*)
Aronia (*Aronia melanocarpa*)
Purple grape (*Vitis* L.)
Cranberry (*Vaccinium macrocarpon*)
Passion fruit (*Passiflora edulis*)
Apricot (*Prunus armeniaca*)
Prune (*Prunus* L.)
Kiwifruit (*Actinidia deliciosa*)
Blueberry (*Vaccinium* L.)
Wolfberry (*Lycium barbarum*)
Pomegranate (*Punica granatum*)
Lychee (*Litchi chinensis*)
Camu camu (*Myrciaria dubia*)
Pear (*Pyrus* L.)
Banana (*Musa acuminata*)
Bilberry (*Vaccinium myrtillus*)

Cell-based Antioxidant Protection in Erythrocytes (CAP-e) Assay

- **A novel assay for evaluation of whether antioxidants in foods are capable of penetrating and protecting cells from oxidative damage.**
- **Assay is qualitative in principle and does allow for semi-quantitative comparisons to standards such as gallic acid, Trolox, and ascorbic acid.**
- **Ideally suited for food and natural products research. (Does not use quercitin as standard.)**

The CAP-e constitutes a cell-based model for antioxidant testing that neither has the complexity of the PMN/monocytes assay, nor the risk of misinterpretation of a tumor cell-based assay.

JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

Comparison of Chemical and Cell-Based Antioxidant Methods for Evaluation of Foods and Natural Products: Generating Multifaceted Data by Parallel Testing Using Erythrocytes and Polymorphonuclear Cells

In the CAP-e assay, the cells are exposed to test products in physiological saline.

The cells are allowed time to absorb compounds from the test product.

Any compounds not absorbed by the cells are then removed from the assay by centrifugation and washing.

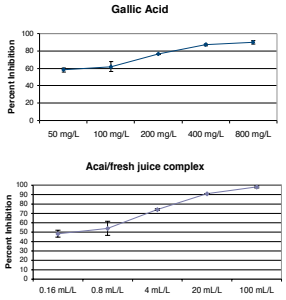
The cells are exposed to a precursor dye that becomes fluorescent if exposed to oxidative damage.

Subsequently, an oxidative challenge (for example H_2O_2) is introduced. The fluorescence intensity equals the amount of oxidative damage.

Positive control wells are exposed to oxidative damage without antioxidant protection, and serve as a measure of optimal oxidative damage.

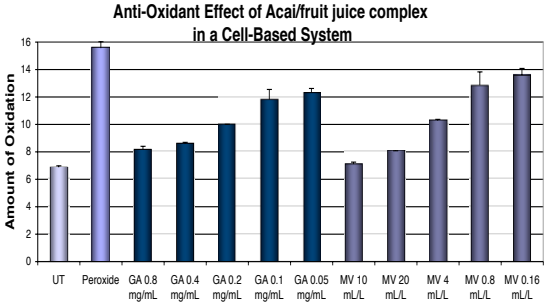
Any reduction of oxidative damage to the cells exposed to the test product is a measure of antioxidant protection.

Açai/fruit Juice Complx Inhibits Oxidation in Assays Using Fresh Human Cells



Anti-Oxidant Effect in Fresh Human Cells

Comparison of acai/fruit juice complex to the antioxidant, gallic acid



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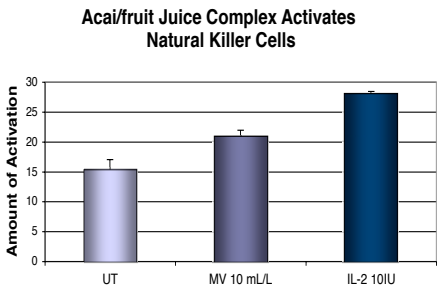
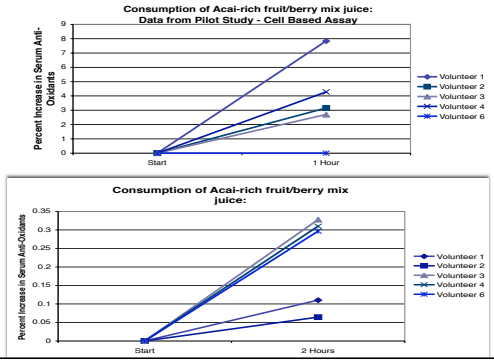
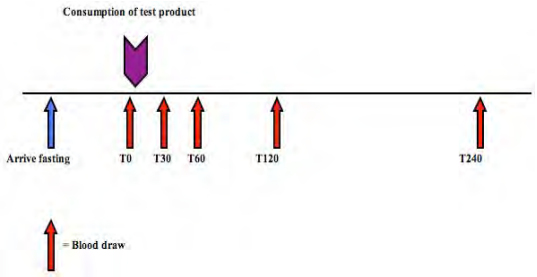
Activation of Natural Killer Cells Demonstrated in Fresh Human Cells



Human Serum Anti-Oxidant Levels in Pilot Study Increased

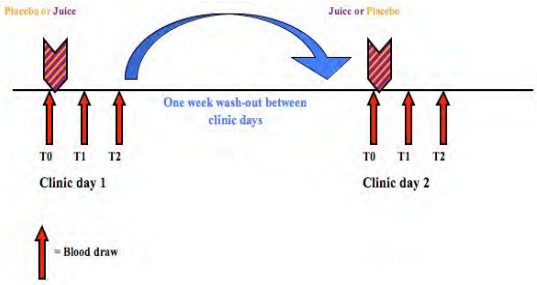


Human Open Label Pilot Study



Randomized, Double-Blind, Placebo-Controlled, Cross-Over Study

(M & F; *n*=12; 19 to 52 years of age)



Results

Drinking 4 ounces of an açai/fruit juice complex resulted in:

1) Increased antioxidant activity;

2) Increased levels of antioxidant compounds entering cells to protect them from oxidative stress (*p*<0.03 1st hour; *p*<0.015 at 2nd hour)

3) 91% of healthy participants had less lipid peroxidation in serum within just 2 hours of consumption compared to placebo (*p*=0.01).

Jensen GS, Wu X, Patterson KM, et al. *In vitro* and *in vivo* antioxidant and anti-inflammatory capacity of an antioxidant-rich fruit and berry juice blend. Results of a pilot and randomized, double-blinded, placebo-controlled, crossover study. *J Agricultural Food Chemistry*, 2008, *56(18)*: 8326-8333.

Both Human Studies Published

These results suggest that açai/fruit juice may have a beneficial antioxidant effect on lipids circulating in blood, warranting further research.

However, one should not extrapolate these results to say this would be true for all individuals until larger clinical trials are carried out.

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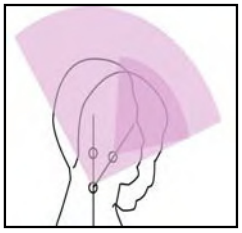
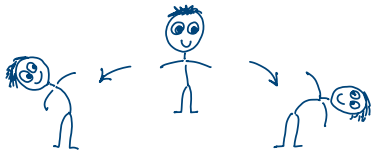
Range of Motion Study

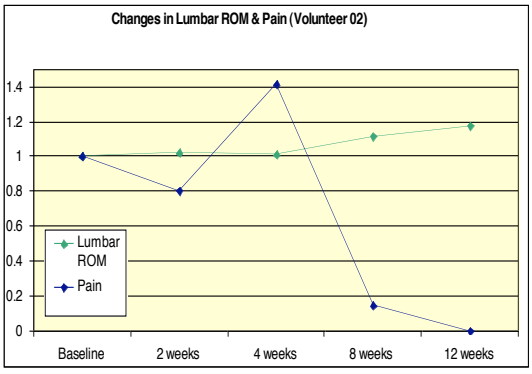
A 3-month study of MonaVie in 14 adult males/ females 44 to 84 yrs

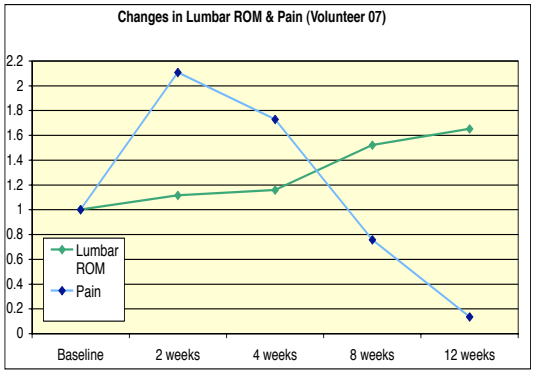


Range of Motion (ROM): Lumbar Motion (Lower Back)



Range of Motion: Knees





Time to Significant Improvement in Range of Motion Drinking 2 ozs Açai/Fruit Juice Twice Daily

	2 weeks	4 weeks	8 weeks	12 weeks
Lower Back (Lumbar)		$p<0.05$		
Left knee				$p<0.0001$
Right knee				$p<0.0001$

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