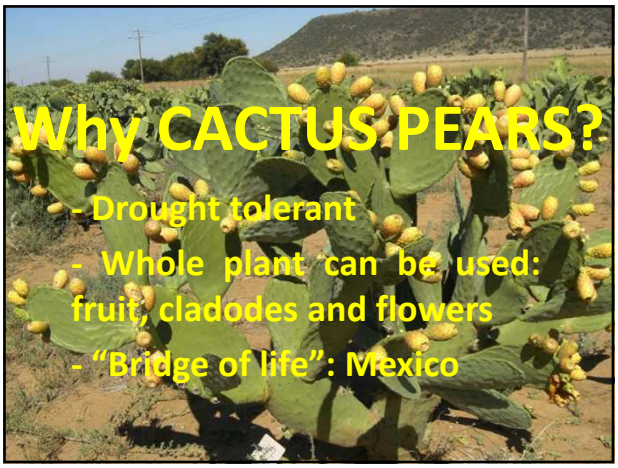




## CHEMICAL COMPOSITION

| Constituent | Cladode (dry mass) (%) | Cladode (wet mass) (%) | Fruit pulp (%) |
|---|---|---|---|
| **Water** | - | **88 - 95** | **84 - 90** |
| **Carbohydrates** | 64 - 71 | 3 - 7 | **12 - 17** |
| Ash | 19 – 23 | 1 - 2 | 0.3 - 1 |
| **Fibre** | **18** | 1 - 2 | 0.02 - 3.15 |
| **Proteins** | **4 - 10** | 0.5 - 1 | 0.21 - 1.6 |
| Lipids | 1 - 4 | 0.2 | 0.09 - 0.7 |
| **Vitamin C** | | 7 - 22 mg | **12 - 81 mg** |
| Calcium | 5.6 mg | | 12.8 - 59 mg |
| Magnesium | 0.2 mg | | 16.1 - 98.4 mg |
| Potassium | 2.3 mg | | 90 - 220 mg |
| Phosphorous | 0.1 mg | | 15 - 32.8 mg |
| Iron | 0.14 µg | | 0.4- 1.5 mg |

## CHEMICAL COMPOSITION

| Constituent | Fruit pulp (%) | Orange | Pawpaw |
|---|---|---|---|
| Water | 84 - 90 | 87.8 | 88.7 |
| **Carbohydrates** | **12 - 17** | **11** | **10** |
| Ash | 0.3 - 1 | 0.4 | 0.6 |
| Fibre | 0.02 - 3.15 | 0.5 | 0.8 |
| Proteins | 0.21 - 1.6 | 0.4 | 0.6 |
| Lipids | 0.09 - 0.7 | 0.1 | 0.1 |
| **Vitamin C** | **12 - 81 mg** | **50** | **50** |
| Calcium | 12.8 - 59 mg | 40 | 20 |
| Magnesium | 16.1 - 98.4 mg | > other fruit | |
| Potassium | 90 - 220 mg | | |
| Phosphorous | 15 - 32.8 mg | = cherry, apricot, watermelon | |
| Iron | 0.4 - 1.5 mg | | |

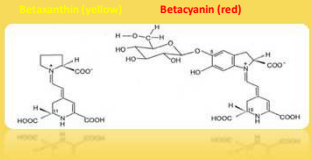
## CHEMICAL COMPOSITION

- Nutritional value same as other fruit
- Energy value same as apple, pear, orange, apricot
- TSS > 16 % (> as prune, apricot, peach, apple, cherry and watermelon)
- Technological properties:

| Parameters | Green pulp | Purple pulp | Importance |
|---|---|---|---|
| pH | 5.3 - 7.1 | 5.9 - 6.2 | Juice |
| Acidity(% citric acid) | 0.01 - 0.18 | 0.03 - 0.04 | Juice |
| Dissolved solids (°Brix) | 12 - 17 | 12.8 - 14.5 | |
| Pectin (g/100g) | 0.17 - 0.19 | - | Juice, marmalade, jelly |
| Vitamin C (mg/100g) | 4.6 - 41.0 | 20.0 - 31.5 | |
| Calcium (mg/100g) | 12.8 - 27.6 | - | |

## CHEMICAL COMPOSITION

- Pigments:
  - betalains




  - carotenes
- Antioxidants:
  - vitamin C
  - betalains
  - phenols
  - carotenes

## USES

- **GENERAL USES:**

- food for humans and animals
- security (fences) and control of soil-erosion
- by-products like humectants, carminic acid, additives, paper
- natural colourants
- flowers
- energy (ethanol + methane gas)
- medical applications
- cosmetics

## USES

- A) **FOOD** USES:

| Cladodes | Fruit |
|---|---|
| - Fodder | - Fresh |
| - Food for cochineal insect (*Dactylopius coccus costa*) – important for carmine dye | - Fresh juice / pulp |
| - Nopalitos | - Jam |
| - Alcohol | - Alcoholic beverages |
| - Jam | - Tuna "cheese" |
| | - Dried sheets |
| | - Liquid sweeteners |

## USES

- A) **NUTRITIONAL** USES:

| Products | | By-products |
|---|---|---|
| **Fruit** | **Cladode** | **Fruit and cladode** |
| - juice and nectar | - brine and pickled | - **oil from seeds** |
| - marmalade, jelly, jam | - **sweets** | - **mucilage from cladode** |
| - dried fruit | - marmalade, jam | - **pigments from skin** |
| - sweeteners | - **flour** | - **dietary fibre from cladode** |
| - alcohol and wine | - sauce | |
| - tinned fruit | - alcohol | |
| - frozen fruit | - edible films | |
| | - **juice** | |

## USES

- B) **MEDICINAL** USES:

| Cladodes | Fruit |
|---|---|
| - anti-viral | - anti- cancer (prevent proliferation of cells and suppress tumor growth) |
| - anti-inflammatory | -anti-oxidants (vitamin C, carotenoids, certain amino acids, betalains) |
| - pain killers (analgesic) | - anti-inflammatory |
| - anti-diabetic (lower blood glucose and haemoglobin levels) | - ulcers, allergies, fatigue, rheumatism, diureticum, "hangovers" |
| - high fibre | |
| - anti-hypercholesterolemia (lower cholesterol and change LDL) | |

## USES

- C) **INDUSTRIAL** USES:

| Cladodes | Fruit |
|---|---|
| - shampoo, face – and skin creams, soap, hair gel, sunscreens | - pulp and skin: natural colourants (betalains) |
| - bio-ethanol, bio-methane gas | - juice: sweeteners and colourants |
| - proteins (76.6% similarity to egg proteins) | - seeds: oils especially unsaturated fatty acids, e.g. Linoleic acid |
| - veterinary phytotherapy | - peels: pectin |
| - carminic acid dye from Cochineal | - juice: single cell proteins |
| | - juice: fermentation substrate (tequila-like, Colonche, Pulque) |
| | - juice: substrate for production of red pigment by *Monascus* |
| | - juice: microbial oil production (poly-unsaturated fatty acids) |

## RESEARCH

In South Africa:

- Most research done on cactus pear as fodder

My group's research:

- Focus on **alternative uses of cactus pear plant** (cladodes, fruits and seeds) in food industry

## Research projects

- **Fruit quality**: mass, % pulp, % juice, pH and acidity, TSS (°Bx), glucose, fructose, vit C
  - Bloemfontein 42, Cradock 14, Oudtshoorn 16 cultivars
  - 12 Corresponding, 2 seasons
- **Fruit juices**: %, 42 cultivars, 2 seasons, heat treatments
- **Seed oils**: % and fatty acid profiles:
  - Bloemfontein 42, Cradock 14, Oudtshoorn 16 cultivars
  - 12 Corresponding, 2 seasons
  - Stability

## Research projects

- **Antioxidants**: betalains, vitamin C, phenols, carotenes (A. du Toit)
  - 42 cultivars (Bfn) fruit (peel, pulp, seeds) and cladodes
  - Processed: 5 cultivars, different fruit colours: juice, dry, chutney, heat-treated, pickled

**Focus on alternative uses of cactus pear plant (cladodes, fruits and seeds) in food industry**

- **Mucilage**: extraction and characterization;

product development and functional properties: mayonnaise, Turkish Delight, marshmallows (A. du Toit & L. du Toit)

## Research projects

- **Pectin**: 6 cultivars, different fruit colours, jelly
- **Cladode flour**: product development:

health bread, rusks, crunchies, traditional fermented drinks (beer and mageu)

- **Cladode juices**: fruit blends and vegetable blends
- **Betalains**: compare beetroot (purple), Robusta (purple), Algerian (red-pink), Gymno Carpo (orange): extraction, % yields, stability (acid and heat) (V. Rammala)

## Projects and products: Fruit


Jellies
Fresh

Chutney

Preserves


## Projects and Products - Cladodes

Chutney

Juice

Pickles


## Flour from cladodes

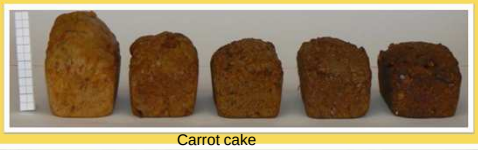
(protein: 3.9% & dietary fibre: 43%)


**Flour from cladodes**

Crunchy cookie processing

(protein: 3.9% & dietary fibre: 43%)

**Projects and Products – Cladode flour**



Carrot cake

"Crunchies"

**Products – Cladode flour**

Health bread

**Projects and Products – Cladode flour**

Flour

Mageu

Beer


**Applications of mucilage as functional ingredients in foods.**

## Projects and Products – Cladode mucilage

Health bread

Carrot cake

## Projects and Products – Cladode mucilage

Turkish Delight

## Projects and Products – Cladode mucilage

Marshmallows

## Projects and Products – Cladode mucilage

Mayonnaise

## Emulsifier in mayonnaise (replacement of egg):


## Fat replacer in mayonnaise (replacement of oil):

Evaluation of **seeds** in terms of:

- Oils and fatty acids (nutraceuticals)
- Proteins and amino acids (nutraceutical & functional foods)

## Antioxidant content:

**Antioxidants** in **unprocessed** cactus pear plants:
-fruit (peel, pulp and seed)
-cladodes

**8 cultivars** (*O. ficus-indica* and *O. robusta**) with different fruit colours:
Green: Nepgen + Morado
Orange: Ofer + Gymno Carpo
Red-Pink: Meyers + Sicilian Indian Fig
Purple: Robusta* (fodder) + Nudosa

**Antioxidants:** (in peel, pulp, seeds and cladodes)
-**Vitamin C (ascorbic acid)** (DPIP titration)
-**Total phenolics** (% gallic acid, spectrophotometric)
- **Betalains: Bc and Bx** (spectrophotometric)
- **Carotenes** (spectrophotometric)

**Antioxidant: able to reduce, delay or inhibit oxidation, in low concentrations**

## Antioxidant content:

**5 cultivars with most antioxidants** (according to colour)**:**
**Processed:juice**
**dried**
**chutney**
**preserves**
**pickles**

**Antioxidant content:** (on processed products)
-**Vitamin C**
-**Total phenolics**
-**Carotene**
-**Betalains**

## Antioxidant potential:

(fresh and processed fruit and cladodes)

- **Activity:** Rate/speed of a reaction between antioxidant and oxidant
- **Capacity:** An amount of free radical scavenged and destroyed by the antioxidant

– **8 un**processed cultivars (fresh)
– **5** processed cultivars

Free Radical Scavenging (**DPPH**)
Chelation of Ferrous ions

**Correlation between content and potential**
**Which antioxidant is responsible for capacity?**

## Processed Products:

**5** cultivars
Nepgen, Meyers, Ofer, Gymno-Carpo and Robusta*

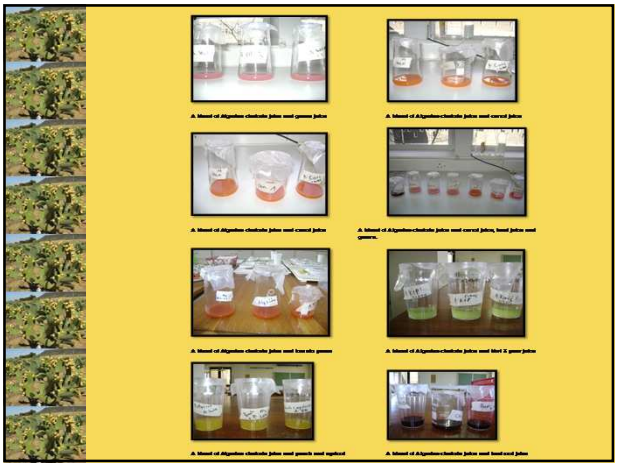
| Juice | Dried | Chutney | Preserves | Pickles |
|---|---|---|---|---|
| • Fruit<br>• Peel<br>• Cladode | • Fruit<br>• Peel<br>• Seeds<br>• Cladodes | • Fruit<br>• Peel<br>• Cladodes | • Fruit<br>• Peel<br>• Seeds<br>• Cladodes | • Cladodes |

## Extraction, characterization and application of mucilage from cactus pear (*Opuntia ficus-indica*), aloe (*Aloe barbadensis*) and agave (*Agave Americana*).

Screen 42 cultivars in order to find cultivars containing the most and least mucilage:

## The suitability of cactus pear cladodes for the processing of a health beverage

| Product | Mango | Beetroot & Strawberry | Kiwi | Guava | Tomato | Significance level |
|---|---|---|---|---|---|---|
| Aroma | 5.58 ± 1.63$^{b}$ | 4.68 ± 1.75$^{a}$ | 6.70 ± 1.52$^{c}$ | 7.28 ± 1.16$^{c}$ | 4.20 ± 1.96$^{a}$ | $p < 0.001$ |
| Taste | 5.60 ± 1.78$^{b}$ | 4.64 ± 1.70$^{ab}$ | 6.94 ± 1.41$^{c}$ | 7.42 ± 1.14$^{c}$ | 4.38 ± 2.44$^{a}$ | $p < 0.001$ |
| Mouthfeel | 5.96 ± 1.76$^{bc}$ | 5.04 ± 1.94$^{ab}$ | 6.90 ± 1.28$^{cd}$ | 7.18 ± 1.49$^{d}$ | 4.66 ± 2.42$^{a}$ | $p < 0.001$ |
| Overall Liking | 5.56 ± 1.89$^{b}$ | 4.56 ± 1.81$^{a}$ | **6.98 ± 1.33$^{c}$** | **7.30 ± 1.36$^{c}$** | 4.38 ± 2.36$^{a}$ | $p < 0.001$ |



## Products

## Locally

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