Bioprocessing of Sweet potato into Food, Feed and Fuel: CTCRI (India) experience

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Introduction

- **Sweet potato (SP): World's 7th most important crop**
- **India: a leading producer of SP- produces more than 1 million tons, annually**
  - **Mostly consumed: fresh vegetable**
  - **Leaves and vines: cattle feed**
  - **Value as a food crop decreasing**
  - **A potential crop for bioprocessing**

Prominent SP Clones

Beta- carotene

ST 14

Anthocyanin

ST 13

Bioprocessing: Food and food additives

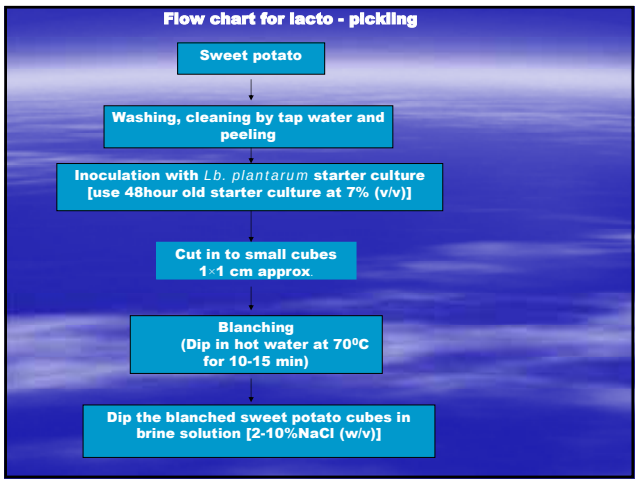
- Lacto- pickle
- Lacto-juice
- SP curd
- SP wine
- Food additives: lactic acid and glutamic acid

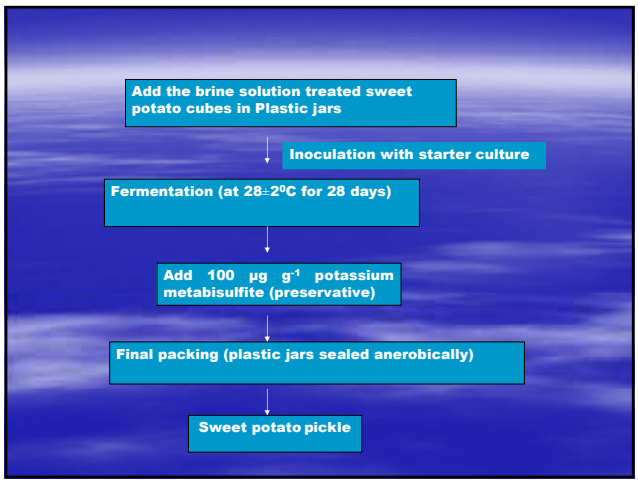
Lacto- pickle

- **Pickling of fruits and vegetables- common to Asian countries**
- *Sauerkraut* **process**
- *Kimchi*: **Fermented Korean cabbage and radish**
- *Grundruk*: **Fermented mustard and radish in Nepal**
- *Dhamuoi*; **Fermented cabbage in Vietnam**
- *Kanji*: **Fermented carrot in India**
- **Fermented cucumber exported from India**

Why lacto- pickling

- **Feasible in small scale**
- **Inexpensive and can be made at home and in cottage industries**
- **Confers organoleptic taste**
- **Adds aroma and flavour**
- **Preserve nutritive components, i.e. ascorbic acid, beta- carotene, anthocyanin, etc.**
- **Bacteriocins produced by LAB kill intestinal pathogenic flora**





pH VALUES OF SWEET POTATO DURING LACTIC ACID FERMENTATION

Equilibrated Salt Concentration (%)	7 Days	14 Days	21 Days	28 Days
2	2.6± 0.1	2.8± 0.4	2.9 ± 0.5	2.1 ± 0.1
4	2.6± 0.1	2.7 ± 0.3	2.5± 0.2	2.1 ± 0.1
6	2.8± 0.3	2.9 ± 0.5	3.0± 0.3	2.9 ± 0.5
8	2.8 ± 0.4	2.9± 0.5	3.1 ± 0.4	2.9 ± 0.5
10	2.9 ± 0.5	3.0 ± 0.3	3.1± 0.4	3.0 ± 0.3

Initial (0 day) pH value of sweet potato roots was 5.5
± Standard deviations

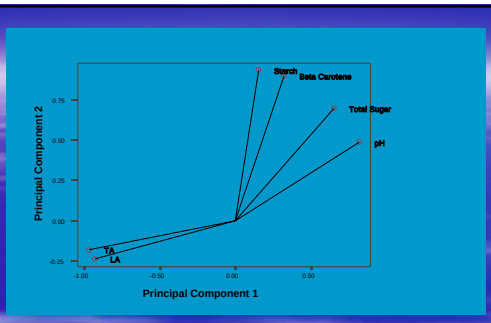
TITRATABLE ACIDITY AND LACTIC ACID* CONCENTRATIONS (g/ Kg ROOTS) OF SP DURING LACTIC ACID FERMENTATION

Equilibr. salt Conc. (%)	7 Days	14 Days	21 Days	28 Days
2	6.6 ±0.5 (4.9± 0.2)	5.7±0.3 (4.7± 0.2)	5.2± 0.2 (4.8 ± 0.3)	5.4 ± 0.2 (4.2 ± 0.2)
4	5.0 ± 0.4 (3.6± 0.2)	5.2 ± 0.2 (4.2± 0.2)	5.2 ± 0.2 (4.4 ± 0.3)	5.2± 0.2 (4.0± 0.2)
6	4.0± 0.2 (3.0± 0.3)	4.4 ± 0.3 (3.5± 0.1)	4.6 ± 0.3 (3.5 ± 0.2)	4.0± 0.3 (3.4± 0.1)
8	3.1± 0.2 (2.6 ± 0.1)	3.1 ± 0.2 (2.0± 0.1)	3.8 ± 0.3 (3.6± 0.1)	3.7± 0.3 (3.2 ± 0.2)
10	2.3 ± 0.1 (1.3± 0.1)	2.4 ± 0.1 (1.6 ± 0.1)	3.0 ± 0.3 (2.9 ± 0.1)	2.9 ± 0.5 (2.6 ± 0.2)

Initial (0 day) titratable acidity/ lactic acid value of sweet potato roots was 0.8 g/kg
* Figures in parentheses indicate the corresponding lactic acid values
± Standard deviations

SENSORY EVALUATION OF THE SWEET POTATO LACTO- PICKLES*

Attributes**	lacto-pickles
Texture	3.5
Taste	4.5
Aroma	4.0
Flavor	3.8
Color/Appearance	3.0
After taste	3.5



GRAPHICAL REPRESENTATION OF PRINCIPAL COMPONENTS (PC1 AND PC2) OF ANALYTICAL VARIABLES. TA- TITRATABLE ACIDITY; LA- LACTIC ACID

LACTO- JUICE

- Lactic –fermented vegetable and fruit juice are alternative to consumers intolerant or allergy to milk protein.
- Cabbage, carrot, celery and tomato-vegetables from which lacto-juice mainly produced.
- SP- rich in starch, Vitamin C, Provitamin A, iron and minerals – suitable for lacto-juice preparation.

Flow chart for lacto –juice preparation

β- Carotene rich sweet potato

↓

Wash, clean in running tap water and peel

↓

Fully-boiled (boiled at 100^{0}C for 15 min) | Non-boiled

↓

Add pectinase enzyme (0.05%) and incubate at room temperature (28± 2^{0}C) for 24 h

↓

Extract the juice

↓

Inoculate with *Lb.plantarum* starter culture [Use 48 h old culture]

↓

Fermentation (at 28°C) for 48 h

↓

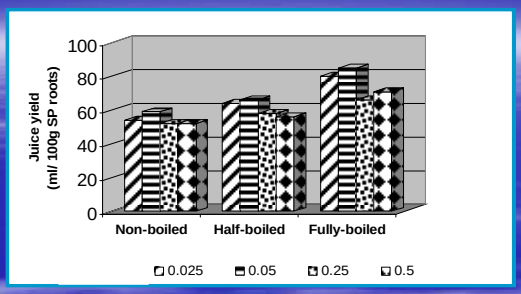
Filter the supernatant, add cane sugar (10%) if desired and add potassium metabisulphite (100 µg ml^{-1})

↓

Fill the bottle and cork

↓

SP lacto- juice



Effect of different concentration (0.025- 0.5%) of commercial pectinase (Pectinex, Novozymes, Denmark) on juice yield from SP roots.

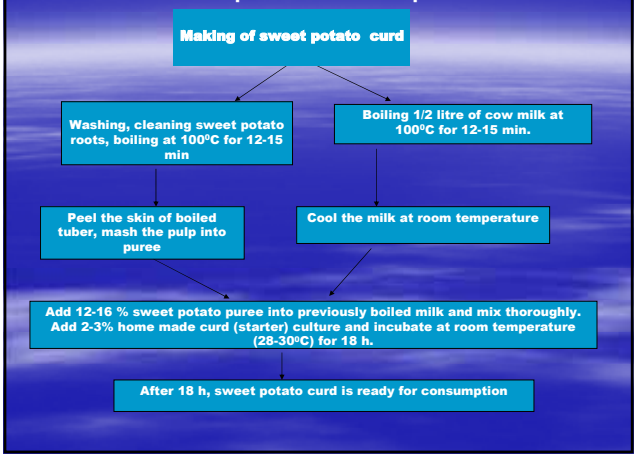
Physiological changes [pH, titratable acidity (TA), lactic acid (LA), starch, total sugar, reducing sugar (g/kg roots), total phenols and β-Carotene (mg/kg roots)] of lacto-juice prepared from fully-boiled and non-boiled SP fermented for 48 h

Treatment of SP	pH	TA	LA	Starch	Total sugar	Reducing sugar	Total phenol	β-Carotene
Fully-boiled	3.3 ± 0.3 (6.1±0.9)	1.23 ± 1.8 (0.8±0.03)	1.19 ± 2.8 (0.7±0.05)	84 ± 3.4 (141±8.9)	11.2 ± 1.6 (21.0±1.3)	3.5 ± 0.7 (7.5±0.3)	317 ± 3.9 (350±3.2)	130 ± 7.5 (140±4.9)
Non-boiled	2.2 ± 0.6 (5.8 ± 0.4)	1.46 ± 1.4 (0.7 ± 0.05)	1.27 ± 1.7 (0.5 ± 0.04)	98 ± 3.8 (145 ± 7.7)	11.9 ± 1.5 (21.4 ± 1.3)	4.2 ± 0.4 (8.0 ± 0.5)	365 ± 3.8 (450 ± 4.3)	155 ± 8.1 (156 ± 5.3)

SP Curd

- Curd and yoghurt: lactic fermented products of milk
- Nutrititive enrichment: French bean, soybean
- Curd: Undefined mixed LAB- *Lb. bulgaricus, St. lactic, St. clemoris,* etc
- Yoghurt: defined LAB inoculum- *Lb. bulgaricus* and *St. thermophilus*

Flow- chart for production of sweet potato curd



pH, TA and LA of β - carotene rich sweet potato curd
(SP + milk mixture fermented for 18h with curd inoculum)

SP(%) in curd	pH	T.A. (g kg^{-1})	L.A.(g kg^{-1})
0	3.88 ± 0.88	12.3 ±0.5	8.0 ± 0.3
4	3.59 ± 0.08	10.6± 0.5	7.9 ± 0.2
8	3.66 ± 0.07	9.9±0.6	7.6 ± 0.1
12	3.60 ± 0.08	11.5 ± 0.5	7.5 ±0.5
16	3.61 ± 0.07	10.5 ± 0.5	6.5 ± 0.4
20	3.66 ± 0.07	11.8 ± 0.5	5.0± 0.5
24	3.57 ± 0.05	10.3 ± 0.7	5.3 ± 0.6

± standard deviation

β-carotene values of sweet potato curd
(SP + milk mixture fermented for 18h with curd inoculum)

Sweet potato in curd	β-carotene (mg kg^{-1})
0	0
4	8.0 ± 0.1
8	14.0 ± 0.2
12	26.0 ± 0.3
16	31.0 ± 0.3
20	38.0 ± 0.3

± standard deviation

Proximate composition of β-carotene rich sweet potato curd *
(SP + milk mixture fermented for 18h with curd inoculum)

SP (%)	Calorie (kcalg^{-1})	Organic matter (g kg^{-1})	Moisture (%)	Protein (g kg^{-1})	Fat (g kg^{-1})	Ash (g kg^{-1})	Dietary fibres (g kg^{-1})
0	5.185	939.2±0.02	88.2±0.01	215.0±4.76	222.0±3.44	60.8±2.34	0
4	5.015	935.1±0.02	88.3±0.01	209.0±4.98	183.0±2.78	64.9±3.44	7.5±0.2
8	4.95	936.2±0.02	86.4±0.01	196.0±3.11	130.0±2.99	63.8±2.78	17.8±0.9
12	4.95	937.1±0.02	85.2±0.01	181.0±3.78	128.0±3.41	73.9±3.21	18.5±1.2
16	4.95	941.7±0.02	85.1±0.01	183.0±4.12	131.0±2.43	58.3±3.98	19.8±1.7

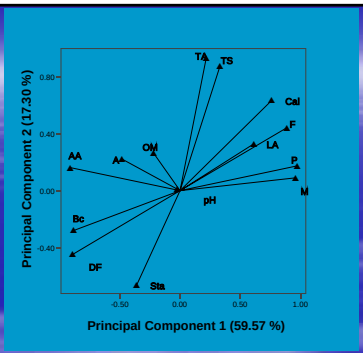
* On dry weight basis
± standard deviation

Lactobacillus counts of sweet potato curd on MRS medium

Sweet potato (%) in curd	Sequences of sampling	MRS[a] ($CFU^{b-1}g$ curd)
8	After fermentation for 6hr	2×10^7
	After fermentation for 18hr	5×10^7
16	After fermentation for 6 hr	7×10^7
	After fermentation for 18hr	14×10^7

[a]MRS – de Mann Rogassa sharpe Agar medium
[b] CFU- Colony forming units.

Lactobacilli colony isolated from SP curd on MRS agar medium



Graphical representation of PCA (PC1 vs PC2) of proximate variables.
AA- Ascorbic acid, BC- β- carotene, DF- Dietary fibre, A-Ash,
OM- Organic matter, Sta- Starch, M- Moisture, P- Protein,
LA- Lactic acid, F- Fat, Cal- Calorie, TS-Total sugar,
TA- Titratable acidity

SP Wine

Food additives

- Lactic acid production in SSF and SmF
- Glutamic acid production in SSF and SmF
- Wine Vinegar from SP red wine

Bioprocessing: Ethanol from SP

Steps

- ❑ **Milling SP Chips or flour**
- ❑ **Liquefaction by treatment with Termamyl^{R}**
- ❑ **Saccharification with AMG**
- ❑ **Fermentation**
- ❑ **Distillation**

Yield: 140g ethanol/kg sweet potato tubers

CONCLUSION

- Bioprocessing – major path for value-addition.
- Beta-carotene and anthocyanin varieties suitable for lacto-pickle, lacto-juice, wine and as ingredient in SP curd.
- Substrate for fermentation : lactic acid, glutamic acid and vinegar.
- Potential crop for bioethanol.

Selected Publications

1. Ray, R.C. and Ravi, V. (2005). Post harvest spoilage of sweet potato in tropics and control measures. Crit. Rev. Food Sci. Nutr. 45: 623- 644.
2. Panda, S.H., Naskar, S.K. and Ray, R.C. (2006). Production, proximate and nutritional evaluation of sweet potato curd. J. Food Agric. Environ. 4: 124 -127.
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5. Ray, R.C., Siva kumar, P.S. and Naskar, S.K. (2005). Sweet potato curd. Technical Bull. No. 39, CTCRI, Thiruvanathapuram, India, 24pp.


Thank you