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ORIGINAL ARTICLE

Preparation and evaluation of sauces from lactic acid fermented vegetables

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Abstract Different combinations of fermented vegetables like carrot, radish and cucumber with pear and mango pulps were made separately and were processed. All the sauces prepared were having a constant TSS of 18°B using different combinations of fermented pulp viz., 25, 50, 75 and 100% with fruit pulps of mango and pear. The titratable acidity of carrot, radish and cucumber based sauces ranged from 1.22 to 1.39%. The blending ratio influenced the titratable acidity, Brix-acid ratio, pH and colour of the various sauces. In general, physico-chemical and sensory characteristics of all sauces prepared met the FPO specifications. Carrot with pear pulp based sauce had the highest overall acceptability. Product prepared with 25% radish + 75% pear and sauce with blend of 50% cucumber + 50% pear were preferred to others. Fermented carrot based sauce having blend of 75% fermented carrot + 25% pear was adjudged sensorily as the best. The cost of production of fermented vegetable based sauces (200 ml bottle) ranged between Rs 15.54 and 24.14 and the lowest (Rs 15.54) cost was for radish based fermented sauce.

Keywords Lactic acid fermentation · Fermented vegetables · Sauces · Pulps

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Introduction

The tremendous increase in consumers demand for fresh like products containing natural ingredients, changing food patterns and convenience have led to the development of minimally processed products using lactic acid bacterial (LAB) cultures. Recently, the presence of bacteriocin-an antimicrobial substance in these products has also attracted the attention of scientists (Luchansky 1999, Jamuna and Jeevaratnam 2004, Joshi et al. 2006). Products like sauerkraut are produced by mixed natural microflora (Joshi and Thakur 2000) while mixed lactic cultures have been employed to study the controlled fermentation of vegetables (Desai and Sheth 1997). Kinetics of lactic acid produced by *Lactobacillus delbrueckii* and *L. bulgaricus* (Chakraborty and Dutta 1999) have also been determined. Lactic acid fermentation using LAB culture is normally employed to prepare fermented grape juice, fermented peanut milk, yogurt, fermented corn meal, sweet potato lacto-pickle besides fermented beverages from wheat and maize (Bucker et al. 1979, Cheng et al. 1990, Takagi et al. 1990, Frazier and Westhoff 1998, Joshi and Thakur 2000, Panda et al. 2007). The LAB fermented products like sauerkraut, and kimchi are well known (Pederson 1971). Ready-to-serve drinks have been prepared from crimson coloured carrots (Sethi 1990) while a sauce was developed from lactic acid fermented mushrooms (Joshi et al. 1996). In our earlier attempt, a process of sequential LAB culture of vegetables was standardized (Sharma and Joshi 2007, Joshi et al. 2008). To develop diversified products especially having healthful properties available to the consumers was considered desirable from fermented vegetable utilization and consumption point of view. Results obtained on various aspects of development and evaluations of sauces from fermented vegetables have been described in this communication.

Material and methods

Carrot (*Daucus carota*), radish (*Raphanus sativus*) and cucumber (*Cucumis sativus*) (3 kg each) were fermented

with cultures of *Lactobacillus plantarum* (NCDC 020), *Pediococcus cerevisiae* (NCDC 038) and *Streptococcus lactis* var *diacetylactis* (NCDC 061) at the rate of 2% sequentially at 26°C containing 2.5% salt (w/w). However for cucumber, fermentation was conducted at 32°C in brine containing 3% salt (Joshi et al. 2008). Fruits of mango (*Mangifera indica*) and sand pear (*Pyrus pyrifolia*) procured locally, were converted into pulp and preserved for later use as per the conventional procedure (Lal et al. 1986).

Sauce was prepared from fermented vegetables and fruit pulps in different combinations as per the standard procedure given by Lal et al. (1986). Fermented carrot and radish were first converted into paste/pulp by adding water in 1:1 ratio in a mixer and used for sauce preparation. The cucumber paste/pulp was made in a mixer without adding water. In the preparation of carrot sauce, fermented carrot pulp and fruit pulp were mixed in different ratios (T_1C: Control {fermented carrot}; T_2CP: 25% fermented carrot + 75% pear pulp; T_3CP: 50% fermented carrot + 50% pear pulp T_4CP: 75% fermented carrot + 25% pear pulp). Similarly, different combinations were employed for radish (T_1R: Control; T_2RP: 25% fermented radish + 75% pear pulp; T_3RP: 50% fermented radish + 50% pear pulp; T_4RP: 75% fermented radish + 25% pear pulp; T_2RM: 25% fermented radish + 75% mango pulp; T_3RM: 50% fermented radish + 50% mango pulp; T_4RM: 75% fermented radish + 25% mango pulp) and cucumber (T_1Cu: Control; T_2CuP: 25% fermented cucumber + 75% pear pulp; T_3CuP: 50% fermented cucumber + 50% pear pulp; T_4CuP: 75% fermented cucumber + 25% pear pulp; T_2CuM: 25% fermented cucumber + 75% mango pulp; T_3CuM: 50% fermented cucumber + 50% mango pulp; T_4CuM: 75% fermented cucumber + 25% mango pulp) based sauces. In the preparation of sauce paste/pulp (1 kg) was heated slowly and the spice bag containing 10 g of coarsely ground cardamom, black pepper, cumin, powdered red chilies, cloves and finely chopped onion (100 g), and garlic (20 g) were placed in paste/pulp during boiling. About one third of sugar (180 g) was added at the time of commencing the boiling. The rest of sugar (37 g) was added a little before the sauce was ready. Salt (10 g) was also added towards the end of boiling. Before adding salt, spice bag was taken out. When the sauce was ready i.e. attained total soluble solids (TSS) 17°B, sodium benzoate (750 ppm) and acetic acid (3 ml/kg or little more as required) were added so that the final product contains more than 1.2% acidity as acetic acid. The sauce was hot filled in pre-cleaned, sterilized, dry glass bottles of 200 ml capacity. Bottles were crown corked and stored at ambient temperature (15–28°C).

Physico-chemical analysis: Sauces of different combinations were analyzed for TSS using Erma hand refractometer (0–32°B), titratable acidity (TA) as per AOAC (1980) and expressed as per cent acetic acid, pH using pH meter (HPG, G-2004) after calibrating it with buffer solutions of pH 4 and 9.2, total sugars and salt content by titration methods while colour by using tintometer (Ranganna 1986) and

Table 1 Physico-chemical and sensory characteristics of fermented carrot based sauces

	Treatments				CD (≤ 0.05)
	T_1C	T_2CP	T_3CP	T_4CP	
Physico-chemical (n = 3)					
Total soluble solids, °Brix	18.0	18.0	18.0	18.0	NS
Titratable acidity, % AA	1.37	1.32	1.37	1.39	0.030
Brix/Acid ratio	13.1	13.6	13.1	12.9	0.237
pH	3.2	3.2	3.2	3.2	0.046
Salt, %	1.9	1.8	1.9	1.9	0.036
Total sugars, %	12.8	14.8	14.7	14.1	0.046
Tintometre colour units					
Red	8.2	5.1	6.4	7.2	0.495
Yellow	10.0	10.0	10.0	10.0	NS
Sensory (score out of 20)					
Colour	17.2	15.6	16.7	17.8	1.41
Consistency	13.9	14.7	15.4	15.1	NS
Flavour	12.8	14.3	16.6	15.6	1.52
Taste	14.4	16.6	17.3	15.4	1.15
Overall acceptability	14.6	15.3	15.6	16.0	1.06

T_1C: Control, T_2CP: 25% fermented carrot + 75% pear pulp, T_3CP: 50% fermented carrot + 50% pear pulp, T_4CP: 75% fermented carrot + 25% pear pulp

AA= Acetic acid, NS =Non-significant, n=10 panelists

expressed as red, yellow and blue tintometer colour units (TCU).

Sensory evaluation: The sensory evaluation of different products was conducted by a semi-trained panel of 10

Table 2 Physico-chemical and sensory characteristics of fermented radish based sauces

	Treatments							CD (≤ 0.05)
	T_1R	T_2RP	T_3RP	T_4RP	T_2RM	T_3RM	T_4RM	
Physico-chemical (n=3)								
Total soluble solids, °Brix	18.0	18.0	18.0	18.0	18.0	18.0	18.0	NS
Titratable acidity, % AA	1.2	1.3	1.3	1.3	1.3	1.3	1.3	0.015
Brix/Acid ratio	15.0	13.9	13.9	13.9	13.9	13.9	13.9	NS
pH	3.5	3.5	3.4	3.4	3.4	3.4	3.5	0.048
Salt ,%	2.0	1.7	1.8	1.9	1.6	1.9	1.9	0.099
Total sugars, %	12.2	12.8	12.6	12.5	13.9	13.7	13.5	0.062
Tintometre colour units								
Red	2.8	2.8	3.0	3.1	4.3	4.3	4.3	0.397
Yellow	10.0	8.0	8.0	6.0	20.0	20.0	21.0	0.146
Sensory (Score out of 20)								
Colour	12.5	13.8	13.3	13.4	14.0	14.1	13.5	0.982
Flavour	13.8	13.6	13.5	12.4	13.4	13.8	14.6	1.08
Consistency	11.8	14.2	13.7	13.6	13.2	13.7	13.9	1.16
Taste	12.2	14.9	13.5	14.6	12.8	14.3	14.1	1.28
Overall acceptability	12.6	14.2	13.5	13.5	13.3	14.0	14.2	0.897

T_1R: Control, T_2RP: 25% fermented radish + 75% pear pulp ,T_3RP: 50% fermented radish + 50% pear pulp, T_4RP: 75% fermented radish + 25% pear pulp, T_2RM: 25% fermented radish + 75% mango pulp, T_3RM: 50% fermented radish + 50% mango pulp, T_4RM: 75% fermented radish + 25% mango pulp, n=10 panelists. AA, NS: As in Table 1

Table 3 Physico-chemical and sensory characteristics of fermented cucumber based sauces

	Treatments							CD (≤ 0.05)
	T_1Cu	T_2CuP	T_3CuP	T_4CuP	T_2CuM	T_3CuM	T_4CuM	
Physico-chemical (n=3)								
Total soluble solids,°Brix	18.0	18.0	18.0	18.0	18.0	18.0	18.0	NS
Titratable acidity % AA	1.2	1.3	1.3	1.3	1.2	1.3	1.3	0.017
Brix/Acid ratio	15.0	13.9	13.9	13.9	15.0	13.9	13.9	NS
pH	3.4	3.4	3.4	3.3	3.4	3.4	3.4	0.092
Salt %	2.2	2.0	2.1	2.1	2.1	2.1	2.2	0.056
Total sugars %	9.8	10.8	10.6	10.6	10.6	12.5	12.5	0.084
Tintometer colour units								
Red	2.2	2.6	2.6	1.7	5.2	5.8	6.4	0.083
Yellow	7.8	8.2	8.6	6.8	2.4	2.4	2.6	0.102
Sensory (score out of 20)								
Colour	13.1	15.5	15.7	15.5	14.2	14.2	14.2	0.918
Flavour	11.4	12.4	14.6	13.5	12.5	13.3	13.5	1.06
Consistency	12.9	13.3	13.5	13.3	12.6	12.8	13.3	NS
Taste	15.7	15.9	16.6	16.0	12.5	12.6	13.1	1.24
Overall acceptability	13.5	14.3	15.1	14.6	12.5	13.2	13.5	0.814

T_1Cu: Control, T_2CuP: 25% fermented cucumber + 75% pear pulp, T_3CuP: 50% fermented cucumber + 50% pear pulp, T_4CuP: 75% fermented cucumber + 25% pear pulp, T_2CuM: 25% fermented cucumber + 75% mango pulp, T_3CuM: 50% fermented cucumber + 50% mango pulp, T_4CuM: 75% fermented cucumber + 25% mango pulp, n=10 panelists. AA, NS: As in Table 1

Table 4 Cost of production of fermented vegetable sauces

	Rate (Rs)	Carrot (T_3CP)		Radish (T_2RP)		Cucumber (T_3CuP)	
		Quantity	Amount Rs	Quantity	Amount Rs	Quantity	Amount Rs
Fermented carrot	25/kg	2.5 kg	62.5	-	-	-	-
Fermented radish	25/kg	-	-	1.25 kg	31.25	-	-
Fermented cucumber	24/kg	-	-	-	-	5 kg	120
Pear fruit	2.5/kg	5.88 kg	14.7	8.82 kg	22.00	5.88 kg	14.7
Sugar	17/kg	385 g	6.50	385 g	6.50	385 g	6.50
Salt	6/kg	70 g	0.42	70 g	0.42	70 g	0.42
Onion	5/kg	700 g	3.50	700 g	3.50	700 g	3.50
Garlic	20/kg	140 g	2.80	140 g	2.80	140 g	2.80
Cardamom	120/kg	23.3 g	2.79	23.3 g	2.79	23.3 g	2.79
Black pepper	240/kg	23.3 g	5.59	23.3 g	5.95	23.3 g	5.59
Cumin	150/kg	23.3 g	3.49	23.3 g	3.49	23.3 g	3.49
Red chillies	90/kg	9.8 g	0.88	9.8 g	0.88	9.8 g	0.88
Cloves	300/kg	7 g	2.10	7 g	2.10	7 g	2.10
Acetic acid	0.21/ml	21 ml	4.41	21 ml	4.41	21 ml	4.41
Sodium benzoate	0.28/g	5.25 g	1.47	5.25 g	1.47	5.25 g	1.47
Bottles*	3/bottle	15	45	15	45	15	45
Crown corks	0.50/ cork	15	7.5	15	7.5	15	7.5
Labels	0.50/label	15	7.5	15	7.5	15	7.5
Total ingredients cost			171.15		147.2		228.65
Processing charges @ 20%			34.23		29.44		45.73
Total cost			205.38		176.64		274.38
Overhead charges @ 10%			20.53		17.66		27.43
Total cost			225.91		194.30		301.81
Profit @ 20%			45.18		38.86		60.36
Net cost			271.09		233.85		362.17
Cost/ 200 ml bottle			18.07		15.54		24.14

*Bottles not taken on returnable basis

Final product 10 litres, 85% pulp recovery from pear fruit

judges. Each judge was given a set of products separately in isolated booths and provided with a glass of fresh water to rinse their mouth before evaluating the next sample. Each sample was evaluated for colour, flavour, consistency, taste and overall acceptability (Joshi 2006).

Statistical analysis: The data of quantitative estimation of various physico-chemical characteristics of different fermented products were anlaysed by completely randomized design taking 3 replicates for each parameters, while that of sensory evaluation were analysed by randomized block designs (O'Mohony 1985). The scores awarded by 10 judges served as replications.

Cost of production: The economics of production (per unit) of sauce at the laboratory scale was worked out by considering the actual cost of all the ingredients, 10% overhead charges, including fermentation charges, 20% processing charges (cost of making puree/pulp/slurry) and 20% profit margin.

Results and discussion

Fermented carrot based sauces: There were non-significant differences among the treatments with respect to TSS (Table 1). The TA ranged from 1.3 to 1.4% as acetic acid with a pH of 3.2 in all the treatments. The differences in TA might be the contribution of acid by the added pulp in combination with the fermented carrot. Fruit/vegetable sauce must have minimum TA of 1.2% as acetic acid (FPO 1955). In fermented mushroom sauce, TA of 1.24% acetic acid has been reported earlier (Joshi et al. 1996). The highest Brix-acid ratio (13.6) in T_2CP might be due to the lowest acidity. The salt content was in the narrow range of 1.8-1.9% in sauces of different treatments. Higher sugar content in different treatments compared to control is attributed to the addition of pulp with higher sugar than the fermented vegetables. As expected, fermented carrot had higher red colour units

The sensory scores of treated carrot based sauces (Table 1) were higher than control and T_4CP was regarded

as the best. Compared to the control the product T_3 CP, was rated as the best with respect to both flavour and taste. Overall, treated products had better sensory scores.

Fermented radish based sauces: The TSS was same in all the products (Table 2). The TA and pH were in the narrow range of 1.2–1.3% and 3.4–3.5, respectively. Brix/acid ratio and salt content were lower and total sugar contents were higher in treated than control. Inclusion of pear pulp (T_2RP, T_3RP, T_4RP) increased tintometer red colour and decreased yellow colour while mango pulp increased both colours compared to control (Table 2).

All the products were sensorily acceptable. Treated products were generally more preferred except flavour scores (Table 2).

Cucumber based sauces: The TSS, titrable acidity, pH, Brix/acid ratio total sugar and salt contents (Table 3) were similar to other sauces. Addition of pulp generally increased tintometer red and yellow (except T_4CuP0 whereas mango pulp increased red and decreased yellow colour (Table 3).

The products with pulp had higher sensory scores whereas mango pulp product, had lower scores for consistency, taste and overall quality compared to control (Table 3).

Cost of production: The comparative cost of production of carrot, radish and cucumber (Table 4) based sauces showed that these products could be prepared at a reasonable cost with an adequate profit margin. The cost per unit (200 ml glass bottle) ranged from Rs15.54 to Rs 24.14. The cost of fermented vegetables was, however, higher than tomato sauce, apparently due to additional cost of fermentation of these vegetables. But these sauces could be projected as products with healthful properties.

Conclusion

Based on physico-chemical and sensory characteristics it is apparent that all the treatments were within the specifications of FPO (1955). The overall acceptability score of T_4 CP (75% carrot + 25% pear) indicates the suitability of this blend for preparation of fermented carrot based sauce. Among others, T_2 RP (25% redish + 75% pear) and T_3 CuP (50% cucumber + 50% pear) were adjudged the best. Irrespective of blending ratios, carrot based sauces ranked the best. Further, in all the fermented vegetable sauces, the pear based carrot, radish and cucumber sauces were rated better. Thus, the utilization of fermented vegetables for preparation of sauces would lead to availability of healthful foods to the consumers at reasonable price.

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