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Studies on utilization of tamarind seed kernel powder as a natural food additive in selected processed foods

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Abstract
Tamarind seed kernel powder is an important by-product of tamarind pulp industry. Tamarind seed kernel powder contains a polysaccharide known as xyloglucan. Tamarind xyloglucan is commonly known as 'tamarind gum'. It is used for thickening, stabilizing and gelling agent in processed food. A study was undertaken to utilize the functional properties of tamarind seed kernel powder as a food additive in the selected processed products. For optimization of tamarind seed kernel powder, it was incorporated at different level in the production of fruit and vegetable based products *viz*., mango RTS, pineapple squash, pineapple jam, guava jelly, tomato ketchup and instant vegetable soup mix. All the products were prepared as per the standard procedures and FSSAI specification. A control sample of each product was also prepared by using pectin for comparison. Organoleptic evaluation studies showed that an optimum incorporation level of tamarind seed kernel powder in the processed foods *viz*., RTS, squash, jam, jelly, ketchup and soup mix was 0.3, 0.4, 1.0, 0.5, 0.2 and 15.0 percent respectively.

Keywords: Tamarind seed kernel powder, nutrients, pectin, processed products, organoleptic evaluation

Introduction
Tamarindus indica L. (Tamarind) is a tropical tree species widely managed for fruit and other exported products in countries like India and Thailand. It belongs to the dicotyledonous sub-family Caesalpinioideae (Leguminosae). It grows in more than 50 countries of the World. The major areas of production are in Asian countries like India, Bangladesh, Sri Lanka, Thailand and Indonesia, and in the African and the American continent. The tamarind tree is a long-lived, large evergreen or semi-green tree, grows wild, though cultivated to a limited extent. A mature tree may attain a maximum height of 30 m. The tamarind tree has the ability to grow in poor soils because of their nitrogen fixing capability and withstanding long periods of drought makes them ideal low input, high yielding trees (Kittiya Klahal *et al*., 2013) [12]. Besides this, tamarind seeds or kernel is a byproduct of Tamarind pulp industry is a valuable raw material containing 30% of testa and 70% of kernel. Tamarind gum is obtained from endosperm of seeds of the tamarind tree, which is a seed gum with potential industrial applications **(**Lokesh *et al*., 2014) [15]. In food industries TKP is used for thickening, stabilizing and gelling agent. It is commercially available as a food additive for improving the texture and viscosity of processed foods (El-Siddig *et al*., 2006*)* [6].

Tamarind decorticated seed kernels contains 46 to 48 per cent of a gel forming substance. Tamarind seed polysaccharide is termed as "jellose" or "polyose" and is found to be superior to other methods of fruit preservation. Jellose is much cheaper than corn starch and is required only in smaller quantities (Gunasena and Hughes, 2000) [8]. Jellose may be used for the preparation of confectionery products, salad dressings like mayonnaise-frozen desserts such as ice cream and ice milk (Vinod, 1997) [19]. The quality of dried food, frozen food, or gel type food is improved by adding polysaccharide hydroxylates of tamarind seeds or xyloglucan oligosaccharides (Shimohiro, 1995) [17]. TKP is also used in the preparation of xyloglucan by enzyme treatment (Kuwano *et al*., 1995) [14], as a health beverage (Tamura *et al*., 1996) [18], used in cakes (Goto *et al*., 1994) [10] and chewing gums (Anon, 1989) [2]. Emulsions containing *κ*-carrageenan and polysaccharides from tamarind seeds are also better stabilized for products like milk preparations such as skim milk, butter, instant coffee, glucose fructose syrup, etc. (Kawaguchi *et al*., 1989) [11].

Jellose gelatinizes with sugar concentrates even in cold water or milk. Unlike fruit pectin, tamarind seed polysaccharide can form gels over a wide range of pHs, including neutral and basic conditions. Tamarind polysaccharides are not affected by boiling in neutral aqueous solutions, even if boiled for long periods.

Fruit pectins undergo degradation on boiling and fall to one-third of the original value after one hour of boiling. Therefore, tamarind polysaccharide can be useful as a gel forming agent, and may be substituted for fruit pectin (Kumar and Bhattacharya, 2008) [13]. Owing to these wide arrays of utility, the present investigation was carried out to study the utilization of tamarind seed kernel powder as a natural food additive in selected processed foods.

Materials and Methods

Physio-chemical analysis of tamarind seed kernel powder

Tamarind seed kernel powder was obtained from Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam. The physio-chemical characteristics of the tamarind seed kernel powder *viz*., moisture, protein, fat, crude fibre, ash, carbohydrate and calorific value was estimated by adopting standard procedure (AOAC, 2012) [3].

Standardizing the optimum incorporation level of tamarind seed kernel powder in the processed foods

Tamarind seed kernel powder was incorporated at different level as a food additive in the preparation of mango RTS, pineapple squash, pineapple jam, guava jelly, tomato ketchup and instant vegetable soup mix. The products were prepared as per the standard procedure prescribed by Girdhari Lal *et al*. (1998) [9] and followed by FSSAI (2006) [7] specification. Pectin was kept as control (standard) for all the products except instant vegetable soup mix. In the instant vegetable soup mix, corn flour (standard) was used as control. The incorporation level of tamarind seed kernel powder and pectin in the production of mango RTS, pineapple squash, pineapple jam, guava jelly, tomato ketchup and instant vegetable soup mix is given in Table-2.

Table 2: Incorporation level of tamarind seed kernel powder as food additive in processed foods

Name of the product	Incorporation level (%)					
	T_0 *	T_1	T_2	T_3	T_4	T_5
Mango RTS	0.2	0.1	0.2	0.3	0.4	0.5
Pineapple squash	0.2	0.2	0.4	0.6	0.8	1.0
Pineapple jam	1.0	1.0	2.0	3.0	4.0	5.0
Guava jelly	0.5	0.5	1.0	1.5	2.0	2.5
Tomato Ketchup	0.2	0.1	0.2	0.3	0.4	0.5
Instant vegetable soup mix	20	5.0	10.0	15.0	20.0	25.0

T_0-Control, T_1 to T_5-Treatment (Tamarind seed kernel powder). *T_0 (Control)-Pectin was used as food additive in mango RTS, pineapple squash, pineapple jam, guava jelly and tomato ketchup whereas in instant vegetable soup mix corn flour was used as food additive.

Organoleptic evaluation was conducted for all the above processed products by using a panel of ten untrained judges (Amerine *et al*., 1965) [1]. A 9 to 1 hedonic scale was used to fix the optimum proportion of tamarind seed kernel powder as a natural food additive in the processed foods by comparing the control sample (standard).

Nutrient content of the standardized processed products

The nutrient content of the optimized level of tamarind seed kernel powder incorporated processed products were estimated by adopting standard procedures (AOAC, 2012) [3]. The nutrients *viz*., TSS, acidity, pH, carbohydrate, total sugars, reducing sugars, ascorbic acid and β-carotene were estimated in mango RTS, pineapple squash, pineapple jam, guava jelly, tomato ketchup and whereas in the instant vegetable soup mix, the nutrients *viz*., moisture, acidity, pH, carbohydrate, ascorbic acid and β-carotene were analyzed.

Results and Discussion

Physio-chemical analysis of tamarind seed kernel powder

The physio-chemical characteristics of the tamarind seed kernel powder *viz*., hygroscopisity, moisture, protein, fat, crude fibre, ash, carbohydrate and calorific value was carried out and the values are given in Table-1. Results showed that tamarind seed kernel powder contained hygroscopisity-4.90 g of adsorbed moisture per 100 g dry solids (g/100 g), moisture-3.59 per cent, protein-18.04 per cent, fat-6.24 per cent, crude fibre-1.61 per cent, ash-2.38 per cent, carbohydrate-68.09 per cent and calorific value-401.13 kcal /100g.

Table 1: Physio-chemical characteristics of tamarind seed kernel powder

S. No.	Characteristics	Values
1.	Hygroscopisity	4.90 g of adsorbed moisture per 100 g dry solids (g/100 g)
2.	Moisture	3.59 per cent
3.	Protein	18.04 per cent
4.	Fat	6.24 per cent
5.	Crude fibre	1.61 per cent
6	Ash	2.38 per cent
7.	Carbohydrates	68.09 per cent

The protein and carbohydrate content of tamarind seed kernel powder was high. Mohamed *et al*. (2015) analysed the nutrient content of light brown (LB) and dark brown (DB) coloured tamarind seeds. The protein and carbohydrate content of light brown (LB) and dark brown (DB) coloured tamarind seeds were 20.23b±0.5658 and 23.75a±0.0839 and 59.303b±0.4041 57.33a±0.2452 respectively. Babli Rani Sarkar *et al*. (2018) analysed the nutritional composition of tamarind seed kernel powder. They reported that the moisture content, crude protein, crude fat, crude fiber and total ash in TKP was found to be 4.67%, 24.61%, 2.46%, 3.70% and 2.50% respectively. TKP had 62.06% carbohydrates and the physiological energy value was recorded as 369 kcal/100g. Similar picture was observed in the present study also.

Standardizing the optimum incorporation level of tamarind seed kernel powder in the processed foods

Mango RTS: For the mango RTS, five concentrations of tamarind seed kernel powder *viz*., 0.1, 0.2, 0.3, 0.4 and 0.5 per cent was added during the production of RTS to serve as thickening agent. The prepared RTS along with control (pectin) were organoleptically evaluated by using ten untrained judges and 9 to 1 hedonic scale. The consumer score values for each level of tamarind seed kernel powder incorporated RTS and control was compared for each attribute for fixing optimum level of tamarind seed kernel powder for mixing with mango RTS (Table-3). The RTS prepared from the incorporation level T_3 had the maximum quality characteristics of 9.0 /9.0 in colour and appearance, flavour, body, taste and overall acceptability with like extremely scores which was onpar with T_0. The other combinations T_1, T_2, T_4 and T_5 were ranked as like moderately to like very much by the judges for quality attributes such as colour and appearance, flavour, body, taste and overall acceptability.

Table 3: Score card for tamarind seed kernel powder incorporated mango RTS

Sensory Characteristics	Incorporation level (%)					
	T_0	T_1	T_2	T_3	T_4	T_5
Colour and Appearance	9.0	8.7	8.9	9.0	8.5	8.4
Flavour	9.0	9.0	9.0	9.0	8.0	7.8
Body	9.0	8.5	8.9	9.0	7.8	7.6
Taste	9.0	8.6	8.8	9.0	7.7	6.9
Overall acceptability	9.0	8.7	8.8	9.0	7.9	7.6

T_0-Control (0.2% pectin), T_1-0.1%, T_2-0.2%, T_3-0.3%, T_4-0.4%, T_5-0.5%

1-Dislike extremely 2-Dislike very much
3-Dislike moderately 4-Dislike slightly
5-Neither like 6-Like slightly
7-Like moderately 8-Like very much
9-Like extremely

Pineapple squash

The incorporation level of tamarind seed kernel powder in the preparation of pineapple squash was 0.2, 0.4, 0.6, 0.8 and 1.0 per cent along with control (pectin) and the organoleptic scores are presented in Table-4. From the organoleptic scores it was observed that the combination T_1, T_3, T_4 and T_5 had like very much to like moderately acceptable scores for colour and appearance, flavour, body, taste and overall acceptability. Whereas the combination T_2 obtained the maximum score for colour and appearance (8.9/9.0), flavour (8.8/9.0), body (8.9/9.0), taste (8.8/9.0) and overall acceptability (8.8/9.0) for the quality attributes hence the T_2 was selected for incorporation level of tamarind seed kernel powder in pineapple squash as a thickening agent. The control-T_0 sample prepared by using 0.2 per cent pectin had 100 per cent (9.0/ 9.0) organoleptic scores.

Table 4: Score card for tamarind seed kernel powder incorporated pineapple squash

Sensory Characteristics	Incorporation level (%)					
	T_0	T_1	T_2	T_3	T_4	T_5
Colour and Appearance	9.0	8.8	8.9	8.7	8.7	8.6
Flavour	9.0	8.8	8.8	8.0	7.6	7.0
Body	9.0	8.5	8.9	8.0	7.8	7.6
Taste	9.0	8.7	8.8	8.5	7.2	6.5
Overall acceptability	9.0	8.6	8.8	8.2	8.0	7.1

T_0-Control (0.2% pectin), T_1-0.2%, T_2-0.4%, T_3-0.6%, T_4 – 0.8%, T_5-1.0%

Pineapple jam

Similar to pineapple squash, pineapple jam was prepared by incorporating tamarind seed kernel powder at different level such as 1.0, 2.0, 3.0, 4.0 and 5.0 per cent were tried and the prepared jam was tested for their quality characteristics and consumer acceptability. The results are presented in Table-5. The control-T_0 sample prepared by using 1.0 per cent pectin had 100 per cent (9.0/ 9.0) organoleptic scores. The pineapple jam prepared with incorporation level of T_1 attained the maximum quality attribute score 8.8/9.0 (97.8%) for overall acceptability compared to other levels. The incorporation level T_2, T_3 and T_4 had scored 7.8/9.0 (86.7%), 7.6/9.0 (84.4%) and 6.8/9.0 (75.6%) respectively for overall acceptability by the judges, whereas the combination T_5 had 6.4/9.0 (71.1%) score.

Table 5: Score card for tamarind seed kernel powder incorporated pineapple jam

Sensory Characteristics	Incorporation level (%)					
	T_0	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
Colour and Appearance	9.0	8.9	8.2	8.0	7.5	7.1
Flavour	9.0	8.8	7.9	7.6	7.2	6.0
Body	9.0	8.6	7.4	7.0	6.5	5.8
Taste	9.0	8.7	8.0	7.3	6.9	6.4
Overall acceptability	9.0	8.8	7.8	7.6	6.8	6.4

T_0-Control (1.0% pectin), T_1-1.0%, T_2-2.0%, T_3-3.0%, T_4 – 4.0%, T_5-5.0%

Guava Jelly

For the preparation of guava jelly, the tamarind seed kernel powder was used at 0.5, 1.0, 1.5, 2.0 and 2.5 per cent levels. The consumer score value for each incorporation level of tamarind seed kernel powder in guava jelly was compared for each attribute for fixing optimum level of tamarind seed kernel powder to prepare guava jelly. The control-T_0 sample prepared by using 0.5 per cent pectin had 100 per cent (9.0/ 9.0) organoleptic scores. The guava jelly prepared with incorporation level T_1 attained the maximum quality attribute score for 8.9/9.0 (98.9%) for overall acceptability compared to other incorporation level. The other treatments *viz*., T_2, T_3, T_4 and T_5 had like very much to like moderately scored as 8.8/9.0 (97.8%), 8.2/9.0 (91.1%), 7.4/9.0 (82.2%) and 7.1/9.0 (78.9%) respectively.

Table 6: Score card for tamarind seed kernel powder incorporated guava jelly

Sensory Characteristics	Incorporation level (%)					
	T_0	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
Colour and Appearance	9.0	9.0	8.8	8.3	8.0	7.6
Flavour	9.0	9.0	8.8	8.2	7.6	7.0
Body	9.0	8.9	8.8	8.0	7.0	6.8
Taste	9.0	8.9	8.7	8.1	7.2	6.5
Overall acceptability	9.0	8.9	8.8	8.2	7.4	7.1

T_0-Control (0.5% pectin), T_1-0.5%, T_2-1.0%, T_3-1.5%, T_4-2.0%, T_5-2.5%

Tomato ketchup

The percentage level of tamarind seed kernel powder incorporated for the preparation of tomato ketchup and the quality evaluation is presented in Table-7. Five levels of treatment and control were tried and the prepared tomato ketchup was tested for the quality characteristics and consumer acceptability. From the organoleptic score, it was observed that the control-T_0 sample prepared by using 0.2 per cent pectin had 100 per cent (9.0/ 9.0) organoleptic scores for all the attributes. The treatments, T_1, T_3, T_4 and T_5 had like very much to like slightly scored as 8.7/9.0 (96.7%), 8.3/9.0 (92.2%), 7.2/9.0 (80%) and 6.9/9.0 (76.7%) for overall acceptability respectively. Whereas the treatment, T_2 obtained maximum scores for all the quality attributes *viz*., colour and appearance 8.9/9.0 (98.9%), flavour 8.9/9.0 (98.9%), body 9.0/9.0 (100%), taste 9.0/9.0 (100%) and overall acceptability 8.9/9.0 (98.9%).

Table 7: Score card for tamarind seed kernel powder incorporated tomato ketchup

Sensory Characteristics	Incorporation level (%)					
	T_0	T_1	T_2	T_3	T_4	T_5
Colour and Appearance	9.0	8.7	8.9	8.5	7.6	7.2
Flavour	9.0	8.8	8.9	8.2	7.5	7.0
Body	9.0	8.6	9.0	8.4	7.0	6.5
Taste	9.0	8.8	9.0	8.2	7.0	6.3
Overall acceptability	9.0	8.7	8.9	8.3	7.2	6.9

T_0-Control (0.2% pectin), T_1-0.1%, T_2-0.2%, T_3-0.3%, T_4-0.4%, T_5-0.5%

Instant vegetable soup mix

Five incorporation level of tamarind seed kernel powder *viz*., 5, 10, 15, 20 and 25 per cent was used for the preparation of instant vegetable soup mix and its score card (soup) is presented in Table-8. The consumer score value for each treatment of soup mix was compared for each attribute for fixing optimum level of tamarind seed kernel powder to be used as food additive. The soup prepared from the treatment T_3 had like extremely score (9.0 /9.0) in all the quality characteristics *viz.*, colour and appearance, flavor, body, taste and overall acceptability with onpar to control (T_0). For the control sample 20 per cent corn flour was used as a thickening agent whereas in the treatment 15.0 percent (T_3) was scored maximum consumer acceptability. Other combinations T_1, T_2, T_4 and T_5 were ranked like very much to like slightly by the judges for quality attributes such as colour and appearance, flavour, taste and overall acceptability.

Table 8: Score card for tamarind seed kernel powder incorporated instant vegetable soup mix (soup)

Sensory Characteristics	Incorporation level (%)					
	T_0	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
Colour and Appearance	9.0	7.0	7.2	9.0	8.0	7.0
Flavour	9.0	7.0	7.4	9.0	7.0	6.2
Body	9.0	6.5	7.0	9.0	7.5	6.0
Taste	9.0	7.0	8.0	9.0	7.5	6.0
Overall acceptability	9.0	7.0	8.0	9.0	7.5	6.0

T_0-Control (20% corn flour), T_1-5%, T_2-10%, T_3-15%, T_4-20%, T_5-25%

Mohamed *et al*. (2015) stated that the tamarind seed polysaccharides form gels over a wide pH range in the presence of sucrose with or without acid and base, while commercial pectin forms gels over a narrow range (acidic) in the presence of sucrose. Although the protein levels in the polysaccharides were higher compared to commercial pectin, their gel formatting ability was found more applicable as compared to commercial pectin. The results of the present study were found to be similar to the earlier studies.

Nutrient content of the standardized processed products

The nutrient content of the freshly processed products *viz*., RTS, squash, jam, jellies, ketchup and soup mixes in control and treated were ranged from moisture-8.17 to 8.96 per cent, TSS-15 to 65º bx, acidity-0.14 to 1.31per cent, pH-3.2 to 6.61, total sugars-17.06 to 63.32 per cent, reducing sugars-6.15to 42.19 per cent, ascorbic acid-3.40 to 70.40 mg/100g and β-carotene-52.43 to 8288.95µg/100g respectively (Table-9). The nutrient content varied between the processed products as per the type and quantity of raw materials used for the preparation of each product. The processed products prepared by using tamarind seed kernel as a natural food additive is presented in the Fig.-1.

Asma *et al.* (2015) [4] revealed that the flour used for biscuit production was from blends of wheat flour and ground tamarind seeds flour. The flour was obtained by blending in the ratio of (100:0; 97:3; 94:6; 91:9; 88:12; and 85:15 (wheat flour: ground tamarind seeds). The nutrient content of moisture, protein, crude fiber and ash in tamarind seeds by-products substituted biscuits increased with increased level of addition of tamarind seeds flour to biscuits. That sensory evaluation of seeds tamarind by-products substituted biscuits containing different levels of tamarind seeds improvement with the increased level of addition of tamarind seeds to biscuits from 3 until 12% compared to the control biscuit for all organoleptic characteristics.

Instant chutney mixes were prepared using TKP as a base (50g). Three blends of instant chutney mix were made following standard recipes which were incorporated to prepare coconut, groundnut and coriander chutneys. All the chutneys were found to be acceptable and no significant difference was observed in the sensory characteristics of chutney using different blends. Incorporation of instant chutney mixes improved the nutritional composition of all the chutneys. A substantial increase could be seen with respect to the protein and calcium content after the addition of instant chutney mix powder (Babli Rani Sarkar *et al*. 2018). Similar trend was observed in the present investigation too.

Table 9: Nutrient content of the processed products

Nutrients	Mango RTS		Pineapple Squash		Pineapple jam		Guava jelly		Tomato ketchup		Vegetable soup mix	
	T_0	**T_1**	**T_0**	**T_1**	**T_0**	**T_1**	**T_0**	**T_1**	**T_0**	**T_1**	**T_0**	**T_1**
Moisture (%)	-	-	-	-	-	-	-	-	-	-	8.17	8.96
TSS (Brix)	15.0	16.0	52.5	52.0	65.0	65.0	65.0	65.4	25.0	25.0	-	-
pH	3.98	3.98	3.2	3.2	3.2	3.2	3.2	3.2	3.9	3.8	6.61	6.46
Acidity (%)	0.27	0.27	1.25	1.20	1.02	0.99	1.00	1.00	1.26	1.31	0.14	0.14
Total sugars (%)	18.05	18.00	51.61	50.76	60.78	60.49	63.32	62.50	18.28	17.06	-	-
Reducing sugars (%)	12.77	12.41	49.80	48.84	21.38	21.11	42.19	41.08	6.28	6.15	-	-
Carbohydrate (%)	7.32	7.78	20.27	21.44	25.46	27.72	29.94	31.43	10.92	10.40	66.24	59.12
Vitamin C (mg/100g)	3.56	3.40	8.58	8.46	27.98	27.59	70.40	65.57	11.56	11.23	39.58	40.70
β-Carotene (µg/ 100g)	107.10	106.59	56.01	52.43	91.69	90.84	64.16	63.27	2997.20	2842.88	8217.95	8288.95

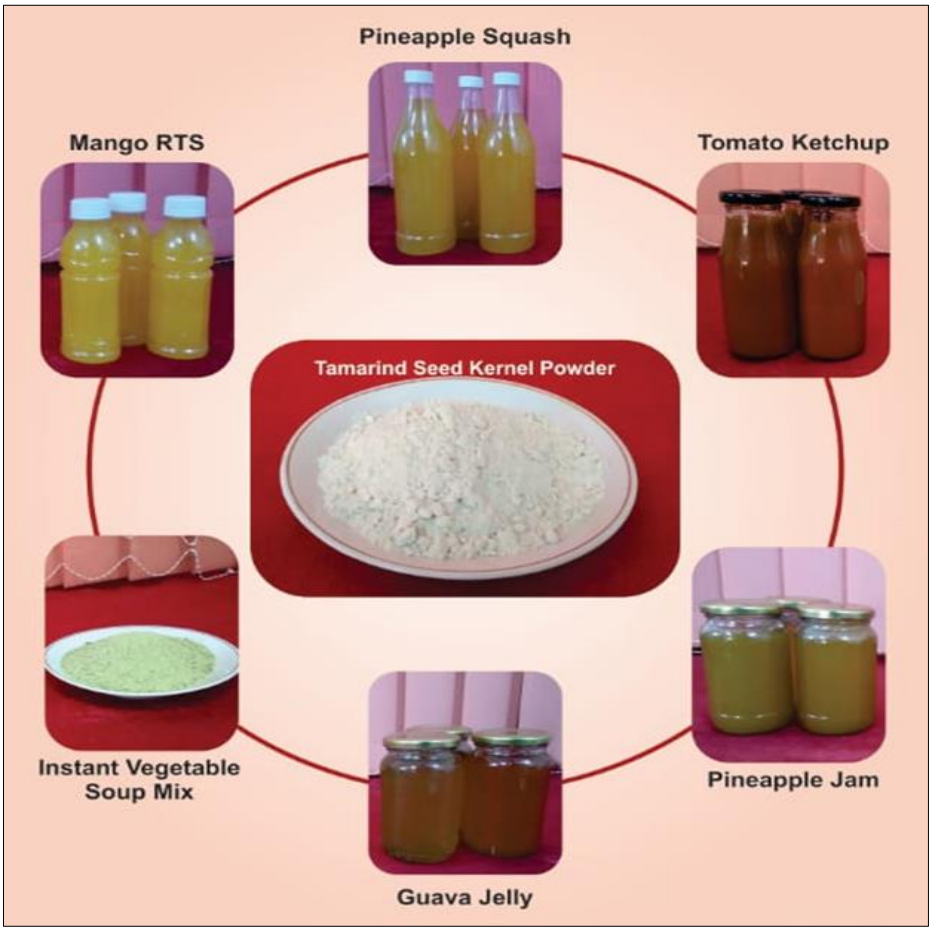

Fig 1: Processed product prepared by using tamarind seed kernel powder as a natural food additive

Conclusion

Tamarind seed kernel powder has many functional properties and on par with the commercial food additive-pectin. It can therefore be utilized as natural food additives for the commercial production of fruit and vegetable based products *viz*., mango RTS, pineapple squash, pineapple jam, guava jelly, tomato ketchup and instant vegetable soup mix. It is apparent from the study that the tamarind seed kernel which is an agricultural by-product has great potential to be exploited optimally in the food processing industries.

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