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Antimicrobial efficacy of mango peel powder and formulation of recipes using mango peel powder (*Mangifera indica* L.)

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Abstract
Peels obtained from fruits are usually discarded or disposed in an improper manner that leads to several environmental problems. Currently, utilization of fruit peels in different ways is gaining attention due to their nutritional and pharmacological properties. Mango peel is a novel source of dietary fibre, polyphenols and carotenoids that can be utilized therapeutically. The present study was carried out to evaluate the antimicrobial efficacy of mango peel powder and to develop nutritious recipes using mango peel powder. The antimicrobial activity of different extracts of mango peel powder (aqueous, acetone and ethanol) indicated that acetone extract exhibited highest antibacterial activity against *E.coli, Salmonella typhi, Shigella spp* and *Enterobacter spp* while ethanol and aqueous extract showed highest antifungal activity against *Aspergillus niger* strain. The peel powder was incorporated into recipes to enrich the dishes nutritionally and the recipes were classified into three different categories namely breakfast, lunch and snacks recipes. The results obtained thereby recommend the use of mango peel as a functional food ingredient due to the presence of components that imparts significant health benefits.

Keywords: mango peel, therapeutic properties, functional food.

1. Introduction
The advent of antibiotic resistance of certain food borne pathogens and the reluctance of consumers towards consumption of chemically treated goods have encouraged the development of safe and natural antimicrobials for food products and treatment of various ailments (Jadhav *et al*., 2013) [10]. Fruit peels are considered to be novel, easily available, efficient, affordable, eco-friendly, natural and economic source for antioxidants and antimicrobial agents and mango peel is one among them. Mango (*Mangifera indica* L.), which belongs to the family Anacardiaceae, is one of the most cultivated fruit in the world. Several million tons of mango wastes are produced annually from factories. Peel that are considered to be by-products from industrial processing or consumption of the fruit contributes about 15-20% of the fruit which is usually discarded as waste (Beerh *et al*., 1976) [8].
Recently, mango peels have attracted considerable attention in the scientific community due to their high content of valuable compounds, such as phytochemicals, polyphenols, carotenoids, enzymes, vitamin E and vitamin C which have predominant functional and antioxidant properties (Ajila *et al*., 2007; Kim *et al*., 2010) [3, 13]. Moreover Sogi *et al*., (2013) [18]. Reported mango peels as a rich source of dietary fibre, cellulose, hemicellulose, lipids, protein, enzymes and pectin. These valuable compounds are also beneficial for human health. Mango peels are used for the production of valuable ingredients. Currently, mango peel flour is used as a functional ingredient in many food products, such as noodles, bread, sponge cakes, biscuits and other bakery products (Aziz *et al*., 2012) [6].
Efforts are continuously taken to improve ways for proper utilization of fruits and vegetables wastes which is causing a serious disposal problem. The reutilization of biological wastes is of great interest since, due to legislation and environmental reasons, the industry is progressively subjected to find an alternative use for its residual matter i.e. seed and peels. The objective of the present study was to evaluate the antimicrobial efficacy of mango peel powder and to enrich day to day life recipes by incorporating mango peel powder and to conduct sensory evaluation for the same evaluation for the same.

2. Methodology: The study was carried out in the following phases:

Phase I: Collection and Authentication of Fruit

Fresh mangoes bright yellow in colour with no bruises were purchased from a local market. The fruits were washed under running water and wiped with clean cloth to dry before peeling. The peels were removed using a sterilized sharp knife. On an average around 200 g of peel was obtained from 1 Kg of mango.

Phase II: Preparation of peel extract

Preparation of peel extracts were carried out by the method described by (Janarthanam and Sumathi, 2010) [11]. One gram of dried mango peel powder were extracted with 20ml of aqueous, ethanol, and acetone were soaked overnight at room temperature which was then filtered through Whatman.No.1 paper in a Buchner funnel. The filtered solution was evaporated under vacuum in a rota-vator at 40 °C to a constant weight and then dissolved in respective solvents. The dissolving rate of the extracts was approximately 100%.

Phase III: Antimicrobial activity of mango peel

Microbial culture

The micro-organisms used for antibacterial activity were *E.coli, Salmonella typhi, Enterobacter* and *Shigella species* and *Aspergillus Niger* for antifungal activity.

Antibacterial activity

The antibacterial test was performed using the agar-well diffusion method (Bauer *et al.,* 1966) [7]. The Muller Hinton agar was prepared and left to cool at 45 °C. Agar plates were prepared using sterile nutrient agar. The bacterial inoculum was evenly spread onto the surface of the agar plates using a sterile cotton swab. Wells were punched in the plates using a sterile stainless steel borer. Test samples were added to each well. Diffusion of the test sample was allowed at room temperature for 30 minutes. The agar plates were then incubated at 37 °C for 24 hours. The plates were observed for the presence of a clear zone around the wells. The size of the zones of inhibition was measured and the antibacterial activity was expressed in terms of diameter of the zone inhibition in millimeters. The absence of a zone inhibition was interpreted as the absence of activity.

Phase IV: Sensory evaluation of mango peel powder

Twenty five recipes were formulated using mango peel powder and their sensory properties were evaluated using a five point hedonic scale. The recipes formulated were categorized into breakfast, lunch and snacks respectively. Twenty post graduate students were chosen as panel members to score the evaluation.

Criteria used for the selection of panel members were

1. Willingness to cooperate and spend time during the study period.
2. Panel members should be free from any oral ailments that could alter the taste sensitivity.

A single portion of each recipe was served in a glass bowl or plate. The judges were instructed to fill the five point hedonic score card. The options on the score card for the evaluation were excellent, very good, good, fair and poor for each sensory attributes such as appearance, color, texture, flavor and taste. A glass tumbler filled with drinking water was provided to rinse the mouth. Individual scores were given for appearance, color, texture, flavor and taste

Description	Score
Excellent	5
Very good	4
Good	3
Fair	2
Poor	1

List of recipes for sensory evaluation

Breakfast recipes	Lunch recipes	Snacks recipes
❖ Alooparatha	❖ Bottle gourd porial	❖ Beet root halwa
❖ Dosai	❖ Cauliflower peas masala	❖ Custard
❖ Idiyappam	❖ Channa masala	❖ Green gram payasam
❖ Kanchipuram idli	❖ Coconut rice	❖ Keasri
❖ Mango chutney	❖ Mango rice	❖ Sprouts salad
❖ Mini idli	❖ Paneer buter masala	❖ Sundal
❖ Ragi adai	❖ Sambar rice	❖ Sweet pongal
❖ Vegetable pasta	❖ Tamarind rice	❖ Vegetable roll
		❖ Yoghurt

3. Results and Discussion

Antimicrobial activity

Different microbial strains were used to screen the possible antimicrobial activity of mango peel powder. The results pertaining to antimicrobial screening assay is presented in (Table 1) and shown in (Plates 1-5). Interpretation of inhibition zones of test culture was adopted from Johnson and Case (1995). A zone of inhibition is an area around the point in the media where the test sample is introduced and where no test organisms (pathogenic bacterial strains) are found to be growing. A diameter of zone of inhibition of 10 or less indicates the test product being resistant to the test organisms (pathogens), diameter zone of inhibition of 11 to 15 indicates the test product having an intermediate resistance to the test organisms. A diameter with a zone of inhibition of 16 or more indicates that test product is highly resistance to test organisms.

The result revealed that acetone extract showed highest inhibitory activity against various food borne pathogens by showing a zone of inhibition of (27mm) for *E.coli,* (15mm) *for Salmonella typhi*, (13mm) for *Sheigella* and (16mm) *for Enterobacter ssp* respectively. The ethanol extract demonstrated moderate activity against *E.coli, Shigella* and *Enterobacter* while the aqueous extract did not exhibit antibacterial activity against any of the food borne pathogens (Figure1-4). The ethanol and aqueous extract exhibited antifungal activity against *Aspergillus Niger* by showing a zone of inhibition of 15mm (Figure 5).

Table 1: Antimicrobial activity of mango peel powder (*Mangifera indica* L.)

Antibacterial activity of mango peel (*Mangifera indica* L.)				
Zone of inhibition (mm)				
Solvents	***E.coli***	***Salmonella typhi***	***Shigella***	***Enterobacter***
Acetone	27	15	13	16
Ethanol	10	0	12	15
Aqueous	0	0	0	0
Antifungal activity of mango peel (*Mangifera indica* L.)				
Zone of inhibition (mm)				
Aspergillusniger	Acetone	Ethanol	Aqueous	
	0	15	15	

Plate 1: Zone of inhibition against Shigella

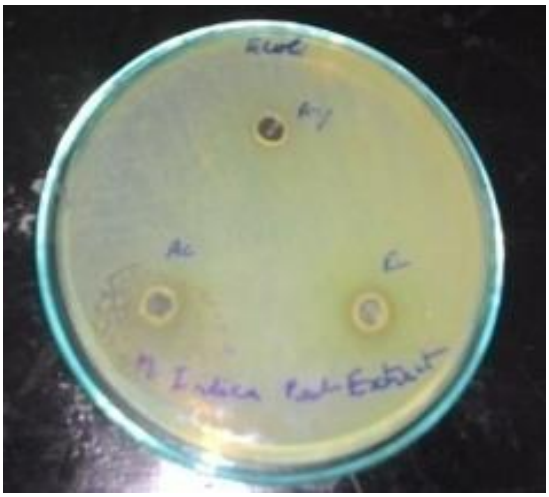

Plate 4: Zone of inhibition against Salmonella typhi

Plate 2: Zone of inhibition against Enterbacter

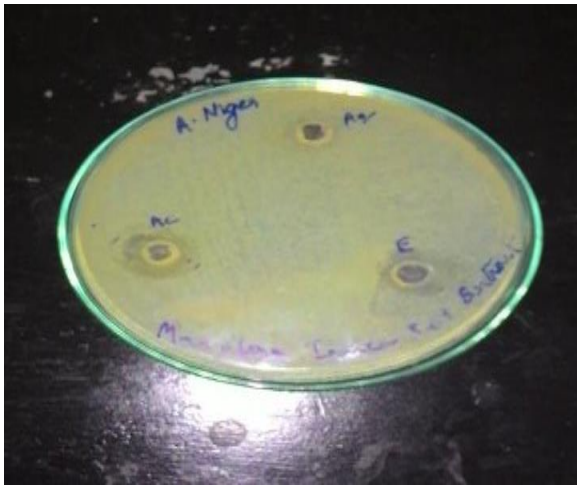

Plate 5: Zone of inhibition against Aspergillus Niger

Plate 3: Zone of inhibition against E.coli

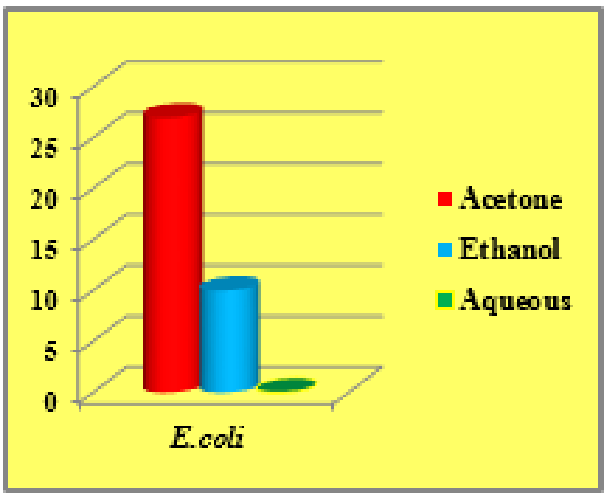

Fig 1: Antibacterial activity against E.coli

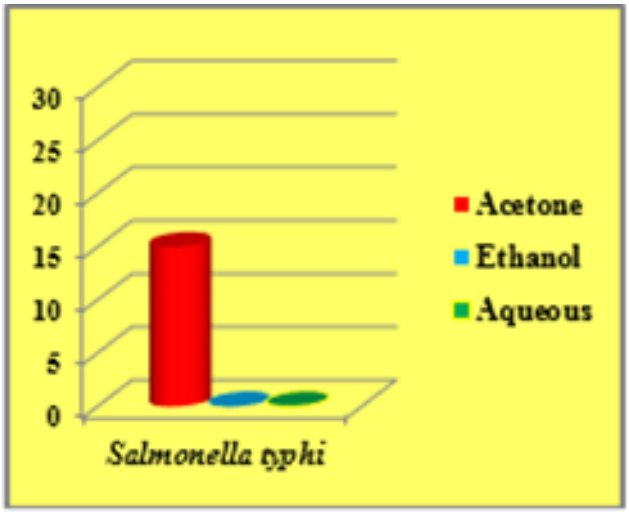

Fig 2: Antibacterial activity against *Salmonella typhi*

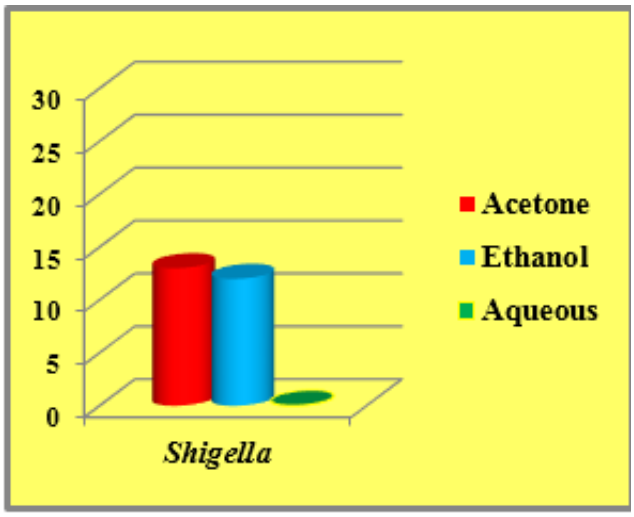

Fig 3: Antibacterial against *Shigella*

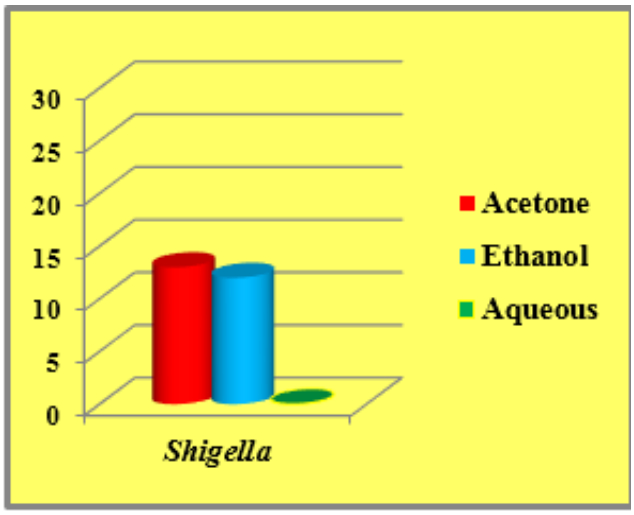

Fig 3: Antibacterial against *Shigella*

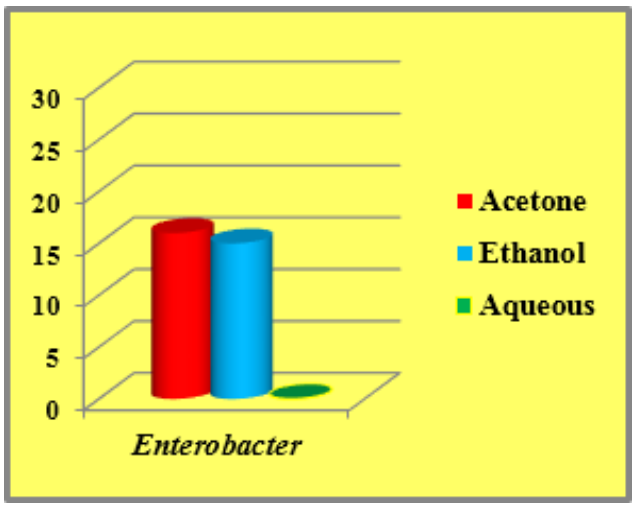

Fig 4: Antibacterial activity against *Enterobacter*

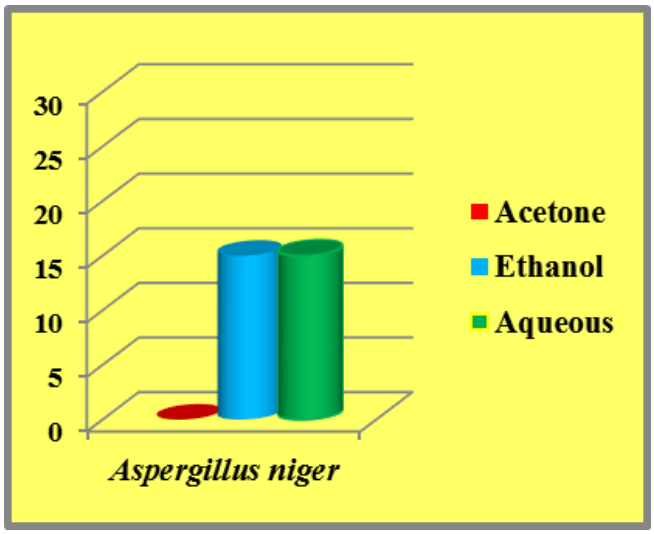

Fig 5: Antifungal activity against *Aspergillus Niger*

Mango peel is a rich source of phenolic compounds, which exhibit antioxidant activity (Palmeira *et al*., 2012) [14]. The major phenolic compounds present in mango peel extract are reported to be syringic acid, quercetin, mangiferin pentoside and ellagic acid (Ajila *et al*. 2010a) [4]. Phenolic compounds are found to have antiviral, antibacterial and anti-inflammatory activity (Zgorka and Kawka 2001) [19].

Ethyl acetate fraction and ethanol crude extracts of mango peel are reported to exhibit strong antifungal activity against pathogenic fungus such as *Rhizoctonia solani* (Qin *et al*., 2007a) [15]. In case of unripe mango peel, superior fungal inhibition was observed with 95% methanol extract than 95% ethanol extract and the inhibition of methylene chloride extract was greater than ethyl acetate (Qin *et al*., 2007b) [16]. The

major component for antifungal activity was found to be 5-(12-heptadeconyl)-resorcinol (Cojocaru *et al*., 1986) [9].

Sensory evaluation of recipes

The recipes made for breakfast were ragi adai, dosai, kanchipuram idli, mango chutney, vegetable pasta, aloo paratha, mini idli and idiyappam. Aloo paratha, dosai, mango chutney, mini idli, vegetable pasta and idiyappam were rated very good on a five point Hedonic scale by taste panel. Ragi adai was rated good as it lost its loss flavour and texture (table 2).

Table 2: Acceptability and palatability of recipes for break fast

S. No	Recipes	Appearance	Colour	Texture	Flavor	Taste
		Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D
1.	Ragi adai	4.2±0.7	3.9±0.9	3.8±0.8	3.5±0.8	3.7±0.5
2.	Dosai	4.3±0.7	4.3±0.8	4.4±0.6	4.5±0.6	4.4±0.5
3.	Kanchipuram idli	4.2±0.7	4.3±0.7	4.2±0.6	4.4±0.6	4.2±0.5
4.	Vegetable pasta	4.7±0.5	4.6±0.5	4.4±0.8	4.5±0.5	4.5±0.6
5.	Aloo paratha	4.8±0.5	4.7±0.6	4.5±0.6	4.7±0.5	4.7±0.6
6.	Mango chutney	4.5±0.6	4.5±0.6	4.5±0.6	4.5±0.5	4.4±0.6
7.	Mini idli	4.2±0.7	4.3±0.7	4.2±0.6	4.4±0.6	4.2±0.5
8.	Idiyappam	4.3±0.7	4.6±0.2	4.1±0.3	4.4±0.7	4.3s±0.7

Overall acceptability of the recipes made for breakfast is depicted graphically in figure 6.The overall acceptability of aloo paratha, vegetable pasta andidiyappam were rated very good by the members of taste panel. Ragi adai was rated good as it was given an overall acceptability score of 3.82 respectively.

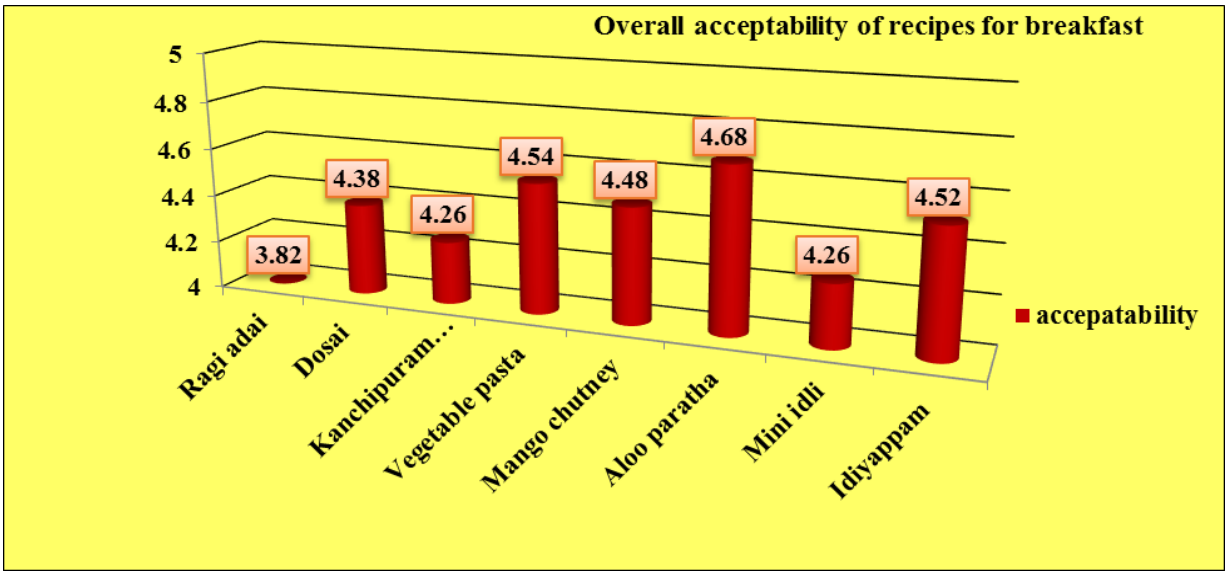

Fig 6: Overall acceptability of recipes for breakfast

The recipes prepared for lunch included rice varieties such as tamarind rice, sambar rice, coconut rice, mango rice, along with side dishes which included paneer butter masala, channa masala and bottle gourd porial. Tamarind rice, coconut rice, paneer butter masala and channa masala were rated very good by the taste panel. Recipes such as mango rice, bottle gourd poriyal and cauliflower peas masala were also were very good as the recipes gave an unique taste when mixed with mango peel powder (table 3).

Table 3: Acceptability and palatability of recipes for lunch

S.no	Recipes	Appearance	Colour	Texture	Flavor	Taste
		Mean± SD	Mean± S.D	Mean± S.D	Mean± S.D	Mean±S.D
1	Sambar rice	4.6±0.6	4.6±0.68	4.5±0.82	4.5±0.6	4.5±0.8
2	Mango rice	4.4±0.8	4.5±0.6	4.6±0.6	4.6±0.5	4.6±0.6
3	Tamarind rice	4.7±0.4	4.7±0.4	4.8±0.4	4.7±0.4	4.8±0.4
4	Coconut rice	4.7±0.5	4.7±0.5	4.6±0.4	4.7±0.4	4.5±0.6
5	Bottle gourd porial	4.5±0.5	4.6±0.5	4.4±0.6	4.5±0.5	4.3±0.5
6	Cauliflower peas masala	4.5±0.6	4.5±0.6	4.4±0.6	4.5±0.6	4.4±0.6
7	Paneer butter masala	4.8±0.4	4.8±0.3	4.7±0.4	4.8±0.4	4.8±0.4
8	Channa masala	4.8±0.6	4.4±0.6	4.3±0.8	4.4±0.7	4.3±0.8

Overall acceptability of the recipes made for lunch is shown graphically in figure 7. Recipes such sambar rice, mango rice, tamarind rice, coconut rice and paneer butter masala were given an overall acceptability score which was greater than 4.5. The overall acceptability score for bottle gourd porial, channa masala and cauliflower peas masala were 4.4 respectively.

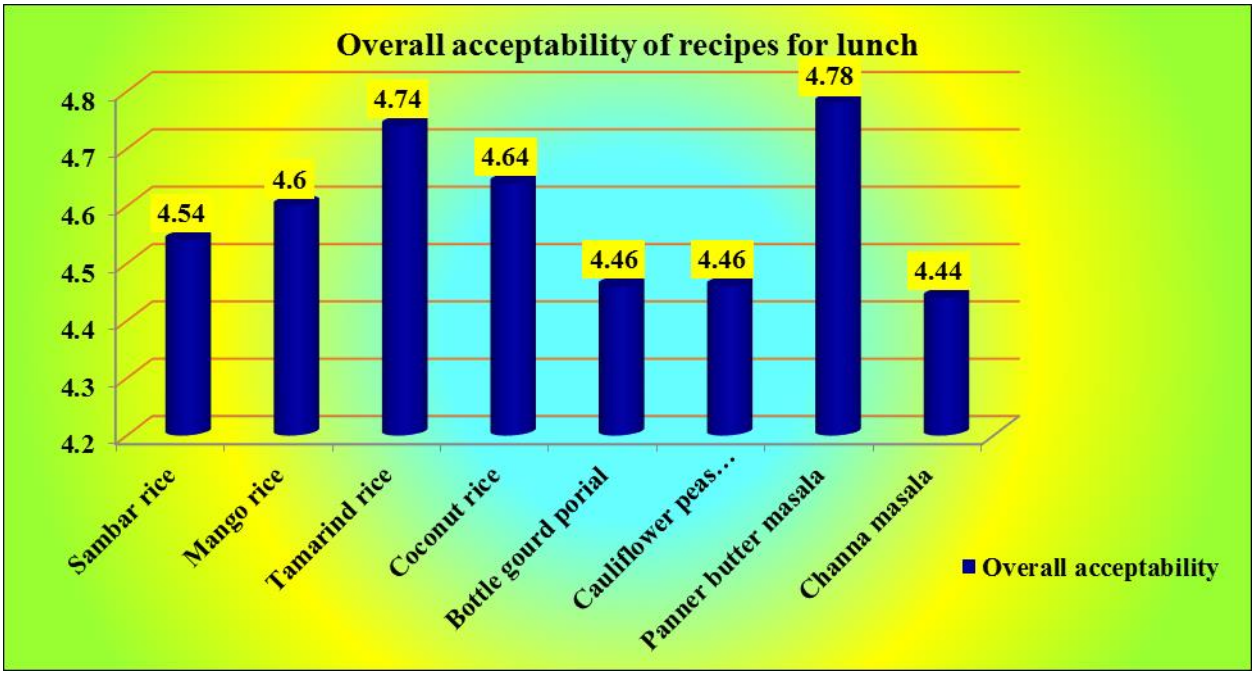

Fig 7: Overall acceptability of recipes for lunch

Recipes formulated for snacks were sundal, kesari, beet root halwa, sprouts, sweet pongal, yogurt, custard, vegetable roll and green gram payasam. The recipes prepared for snack were rated very good on a five point hedonic scale by the members of taste panel (table 4).

Table 4: Acceptability and palatability of recipes for snacks

S. No	Recipes	Appearance	Colour	Texture	Flavor	Taste
		Mean±S.D.	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D
1	Sundal	4.9±0.3	4.8±0.3	4.7±0.7	4.8±0.3	4.7±0.7
2	Kesari	4.8±0.3	4.8±0.5	4.8±0.3	4.8±0.5	4.8±0.3
3	Custard	4.2±0.8	4.1±0.7	4.2±0.6	4.2±0.6	4.2±0.6
4	Yogurt	4.5±0.7	4.1±0.7	4.2±0.6	4.2±0.6	4.2±0.6
5	Green gram payasam	4.5±0.7	4.6±0.5	4.6±0.4	4.5±0.7	4.6±0.6
6	Sweet pongal	4.8±0.3	4.9±0.2	4.9±0.2	4.8±0.3	4.9±0.2
7	Beet root halwa	4.8±0.4	4.8±0.3	4.7±0.4	4.8±0.4	4.8±0.4
8	Sprouts	4.8±0.4	4.7±0.4	4.7±0.4	4.7±0.4	4.7±0.4
9	Vegetable roll	4.8±0.4	4.4±0.6	4.3±0.8	4.4±0.7	4.3±0.8

Overall acceptability of the recipes made for snacks is shown graphically in figure 8. Food items such as sundal, kesari, sweet pongal, beetroot halwa and sprouts were given an overall acceptability score which was greater than 4.7. Custard was given an overall acceptability score of 4.18 as there was no inclusion of fruits and the consistency of the custard was found to be very thick. Similarly yoghurt was given an overall acceptability score of 4.24 as the colour of the yoghurt was not found to be appetizing.

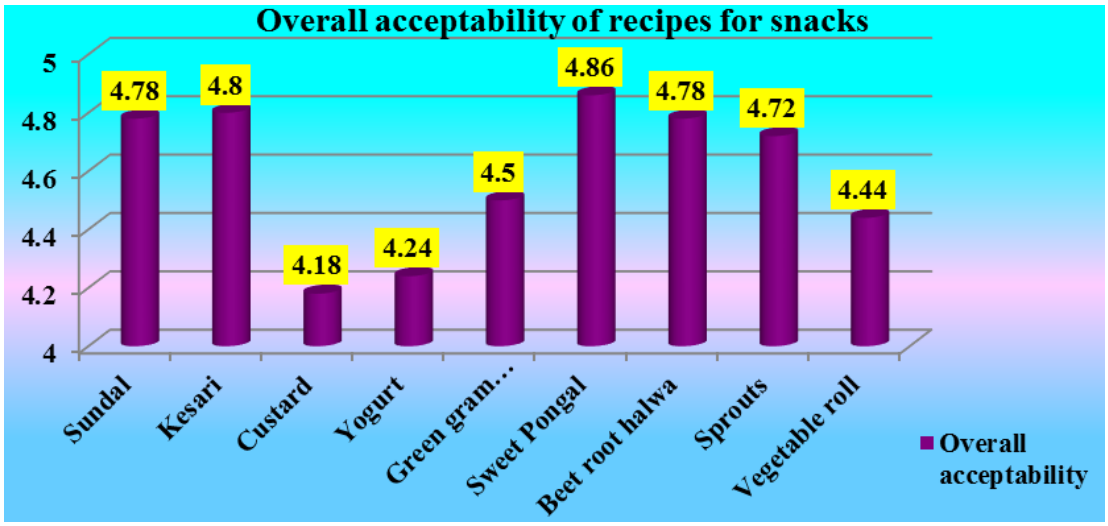

Fig 8: Overall acceptability of recipes for snacks

Mango peel extracts are proved to be a good source of polyphenols, anthocyanins and carotenoids. Sogi *et al*. (2013) [18]. Reported mango peels to be a rich source of dietary fibre, cellulose, hemicellulose, lipids, protein, enzymes and pectin that are beneficial for human health. Mango peels are used for the production of valuable ingredients in food industry. Currently, mango peel flour is used as a functional ingredient in many food products, such as noodles, bread, sponge cakes, biscuits and other bakery products (Ajila *et al*., 2007; Aziz *et al*., 2012) [3, 6].

Ajila *et al*. (2010) [3]. Studied the effects of mango peel added to macaroni and its effect on the cooking properties, firmness, nutraceutical and sensory characteristics of the macaroni. The results suggested that the incorporation of mango peel powder improved the nutritional quality of the macaroni without affecting its cooking, textural or sensory properties.In a study, yogurt made with supplementation of 10% of mango peel powder showed a good texture, flavour and color characteristics and exhibited one month shelf life without adding preservatives (Ruiz *et al*. 2011) [17]. In another study, beef burger samples incorporated with 3% level of mango peel dietary fiber exhibited satisfactory quality grade for all characteristics (Abdeldaiem and Hoda 2012) [1].

The effect of mango peel powders at differing amounts (5%, 10%, 15% and 20%) and mango kernel powders at 20%, 30%, 40% and 50% on the rheological, physical, sensory and antioxidant properties of biscuits was evaluated by Ashoush and Gadallah (2011) [5]. The results showed the possibilities of improving the nutritional quality and antioxidant properties of biscuits by incorporating mango peels and kernel powders.

4. Conclusion

The present study clearly highlights that mango peel powder possess great nutraceutical potential which was exhibited through its effective antimicrobial activity against various food borne pathogens thereby indicating its use as a nutritional and therapeutic agent in food industry. The study also recommends the use of mango peel powder in day to day life recipes as it enriched the recipes nutritionally and also gave an unique taste and flavour to the dishes.

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