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Processing & utilization of fruits and vegetable in cereal, legume and pseudo cereal based composite bars

Monika Mathur and Anju Kumari

Abstract
Cereal bars are loaded with iron and multivitamins can be considered as a functional food when they are mixed with processed products of fruits and vegetables. Different fruits, vegetables and its peels were processed into powder and candies. All processed ingredients were evaluated for proximate composition, dietary fibre, total phenolic content, antioxidant activity and antinutritional factors. Maximum moisture content was observed in pumpkin candy, protein in bottle gourd powder, carbohydrate in lemon peel candy and energy in pumpkin candy. While, fat, ash, and fibre were highest in carrot powder. Calcium was found maximum in carrot powder (45.20mg/100g) and iron (5.64mg/100g) zinc (3.56mg/100g) in bottle gourd powder. Total soluble (6.01mg/100g) and insoluble fibre (17.02mg/100g) was found maximum in bottle gourd and carrot powder, respectively. In functional properties bulk density (0.37g/ml) of mango chunks and water absorption (3.96ml /g) and swelling power (130.8%) of carrot powder were observed maximum, respectively. Maximum amount of phytic acid (63.80mg/100g) in carrot powder was recorded. Lemon peel candy was found to have a higher amount of tannins (27.99mg/100g), total phenolic content (34.61mg/100g) and antioxidant activity (86.38%). Carrot candy and lemon peel candy scored highest score for sensory evaluation, so selected for final preparation of fibre and protein enriched composite bars.

Keywords: Fruit, vegetable candy, powder, multigrain, cereal, bar, composite

Introduction
The snack food bars contain good sensory and nutritional characteristics but many snack food products are available in the market, which does not meet the requirement of a balanced diet. Such snacks are unhealthy offerings for consumers, especially school-going children. Increasing demand from consumers for nutritious snacks has provoked the food manufacturers to develop food bars that provide nutrition and convenience. The higher positive attitude towards healthy foods could constitute the first step in a behavioral change in favour of healthier choices (Poquet *et al.*, 2020) [38]. As snacks are convenient so they attract the attention of children, adolescents, and high-energy cereal bars are highly nutritious and they play an important role for better mental and physical development. Food consumed by them should be rich in vitamins, minerals and balanced regarding major nutrients like carbohydrates, proteins and fats. The options available for the children to buy wholesome and nourishing food products are very limited. This gap needs to be overcome by developing products that c5onform to emerging trends of nutraceutical and functional foods (De Irala-Estevez *et al*., 2000) [15]. Food products prepared by utilizing dried fruits, processed cereals, legumes, millet and pseudocereals along with nuts would be a nutritious snack for the school going children, working professionals and sports person those needs daily requirement of high protein less calorie (Chavez-Jauregui *et al*., 2003) [10]. Some consumers like working people, sports person do not have enough time and want something they can eat quickly that will delay the hunger for a certain amount of time, also some overweight consumers think that eating a bar or two instead of one-time meal will help with weight control (Miraballes *et al.*, 2014) [32]. Many different types of snack bars are available in the market but cereal bars are gaining popularity among consumer as these bars are loaded with required nutrients and functional components. Cereal bars enriched with iron, vitamin A, vitamin E and fibre are healthy and can be considered as a functional food due to the higher levels of easily accessible nutrients (Covino, 2012) [13]. Also because eating fruits and vegetables has a positive effect on the health of human beings and they are power-packed with micronutrients and antioxidants (Njike *et al*., 2016) [36]. So, fruits and vegetable byproducts, their powders, candies can also be incorporated in bars to increase the value addition and their functional value.

These bars are manufactured with cereal grains like amaranth, oat and finger millet with the addition of other ingredients such as whole-grain cereals, flaked grains, fruits, legumes, dehydrated or crystallized fruits, nuts, fruit and vegetable candies, chocolates, sugar etc. (Lobato *et al.*, 2012) [29]. Whole grain not only provides nutrition, but also gives health-promoting effects in food, such as anti-carcinogenic, antimicrobial, and antioxidant properties (Adebo & Gabriela, 2020) [3].

Material and Method

Processing of fruits and vegetable

Carrot, pumpkin, lemon peel, kinnow peel, bottle gourd, banana & mango were processed further: Lemon peel, orange peel, carrot were processed to prepare candies

Flow chart

Fresh fruit (carrot, pumpkin, lemon or orange peel)
↓
Washing and peeling
↓
Slicing and pricking
↓
Hot water treatment (95 ^{0}C for 1 minute)
↓
Steeping in 45°Bx osmotic solution (as per treatments) for 24 hours
↓
Raising syrup strength gradually to 65°Bx
↓
Draining of osmotic solution (after 24 hours)
↓
Spreading slices on trays
↓
Drying overnight in tray drier (55 ^{0}C)
↓
Packing and storing

Powders were prepared using pomace of fruits and vegetables, than drying in tray drier at 60 ℃. Than processed candies and powders were analyzed for further nutritional composition.

Proximate composition

Moisture

Moisture content was calculated by employing the standard methods of analysis (AOAC, 2000).

Procedure: Ten gram sample was weighed in a petri dish and dried in an oven at 60 ^{o}C temperature for six hours or till a constant weight was obtained. The sample was reweighed after cooling in desiccators.

$$\text{Moisture (\%)} = \frac{\text{Loss in weight (g)}}{\text{Weight (g) of sample}} \times 100$$

Crude Protein

Crude protein was estimated by standard Micro-kjeldahl method of analysis (AOAC, 2000) using automatic KEL-Plus CLASSIC-DX apparatus.

Reagents

1. Hydrochloric acid (N/10)
2. Boric acid (4%)
3. Sulphuric acid (concentrated)
4. 40% NaOH (Sodium Hydroxide) solution
5. Digestion mixture: Potassium sulphate (10g) and copper sulphate (2g) were mixed together.
6. Mixed indicator solution: Dissolved 0.3g of bromocresol green and 0.2g of methyl red in 400ml 90% ethanol and the solution was adjusted with drops of dilute NaOH to bluish purple colour.

Procedure

A 200mg sample was taken and digested with 10ml concentrated H_2SO_4 and 3g of digestion mixture was added to the sample. Digestion tubes were loaded into the digester and heated the block at 420°C. Digestion was carried out for about one hour and forty minutes till the contents became colorless or light green. The digested samples were cooled at room temperature and distilled in Classic-DX. During distillation, the digested samples were heated by passing steam and 40% of sodium hydroxide was discharged to liberate ammonia. Liberated ammonia was titrated against 0.1 N HCl until the endpoint was indicated by change of color to light ink. Titrated volume of a blank solution of boric acid and mixed indicator was also determined.

$$\text{Nitrogen (\%)} = \frac{\text{Titre volume(S-B)} \times \text{Normality} \times 14}{1000 \times \text{W}} \times 100$$

Crude protein (%) = Nitrogen (%) × conversion factor

Where,
W = Weight of sample taken (g)
S = Volume (ml) of HCl (N/10) used in titration for sample
B = Volume (ml) of HCl (N/10) used in titration for blank
Conversion factor of 6.25, 5.7, 5.83 and 5.3 was used for maize, wheat, oat & barley to calculate.

Crude Fibre

Crude fibre was estimated by the standard method of analysis (AOAC, 2000) using automatic Fibra-Plus apparatus.

Reagents

1. Sulphuric acid stock solution (10%, w/v): Diluted 55ml concentrated sulphuric acid to one litre.
2. Sulphuric acid working solution (1.25%): Diluted 125ml of stock solution to 1 litre.
3. Sodium hydroxide stock solution (10%) w/v: Dissolved 100g of NaOH in distilled water and diluted to one litre.
4. Sodium hydroxide working solution (1.25%): Diluted 125ml stock solution to one litre with distilled water.

Procedure

One gram of fat free dried sample was weighed and transferred into crucible. The crucibles were fixed in apparatus and proper sealing was ensured. Individual valves were kept in close position. Dilute acid was poured from the top of the extractor through a funnel. The power supply was switched on in the control panel. The temperature was set to 500 °C and when boiling was ensured, the temperature was reduced to 400 °C and boiling was carried out for 45 min.

After that, oven supply was switched off. All the knobs were put in open position and the suction pump apparatus was switched on. Filtration of acid reagent was ensured through the crucibles. The sample was washed with distilled water. Similar process was repeated with dilute alkali. The crucibles were removed and dried in a hot air oven at 70°C for overnight. The crucibles were cooled in desiccators and weighed. The residue was ignited in a muffle furnace at 500°C for 2 h. The crucibles were cooled in desiccators and weighed again. Crude fibre then was determined by loss in weight due to ignition:

$$\text{Crude Fibre (\%)} = \frac{W_1 - W_2}{W} \times 100$$

Where,
W = Weight (g) of sample
W_1 = Weight of crucible + weight of treated sample after oven drying
W_2 = Weight (g) of crucible + weight of sample after ashing

Crude Fat
Crude fat was estimated by standard method (AOAC, 2000) using the automatic SOCS Plus Solvent extraction system.

Procedure
The beakers were washed thoroughly and dried in a hot air oven at 60°C. Weight of the empty beaker was taken. Dried sample (2gm) transferred to an extraction thimble. The thimble holder along with the sample was kept into the beaker along with 100ml of petroleum ether (boiling point 60-80°C). Loaded the beakers into the system and set 90°C temperature in the control panel. The extraction was carried out for one hour at 90°C. When the extraction period got completed. The temperature was raised at 180°C; the stopper was closed in order to collect the solvent in the solvent compartment. The beaker containing fat was removed and kept in a hot air oven 60°C temperature, until a constant weight was obtained. The beaker was weighed after cooling it in a dessicator.

$$\text{Fat (\%)} = \frac{W_2 - W_1\,(g)}{W\,(g)} \times 100$$

Where
W_1 = Weight of empty beaker
W_2 = Weight of beaker after extraction
W = Weight of sample

Ash
Ash content in the sample was estimated by employing the standard method of analysis (AOAC, 2000).

Procedure
Five gram of dried sample was taken in a weighed crucible and ignited until no charred particles left back in the crucible and then the crucible was put in a muffle furnace (550 °C) for 6 h or until a white ash was obtained. Thereafter, the crucible was cooled in a desiccator and reweighed. The loss in weight represents the organic matter residue, the ash content, which was calculated using following formula

$$\text{Ash (\%)} = \frac{W_2 - W_1}{W} \times 100$$

W = Weight (g) of sample
W_1 = Weight (g) of crucible
W_2 = Weight (g) of the crucible + ash

Nitrogen free extract
Carbohydrates content was calculated by difference method AOAC (1995) on dry basis using following formula:
Total carbohydrates % = 100 – (crude fat% + crude protein% + ash % + crude fibre %)

Energy
Energy was calculated by factorial method on a dry basis using the following formula.
Energy (kcal) = 4.0 x protein (g) + 4.0x carbohydrate (g) + 9.0 x fat (g).

Mineral content
Mineral content of the sample was determined by a wet digestion method. One g flour was weighed and dispersed in a 150ml conical flask. 25-30ml diacid mixture (HNO_3**:**$HCLO_4$) in ratio 5**:**1 was added in flask and kept for overnight. The contents were digested by heating until clear white precipitates snuggled down at the bottom. The crystals left were dissolved by adding double distilled water. Then the contents were filtered through what man # 42 filter paper and the filtrate was made to 50ml volume by using double distilled water and used for the determination of trace minerals: iron and zinc, using atomic absorption spectrophotometer (Lindsey & Norwell, 1969) [28], in the Department of Soil Science, CCS Haryana Agricultural University, Hisar.

$$\text{Minerals (mg/100g)} = \frac{\text{Reading (conc. µg/ml)} \times \text{volume made}}{\text{Weight of sample (g)} \times 1000} \times 100$$

Calcium
Total calcium in acid digested samples was determined by the method of Chopra & Kanwar (1979) [11].

Reagents
1. Standard solution of Ca (0.01 N): 0.5g of well dried pure $CaCO_3$ was transferred to 400ml beaker and added 10ml of 1N HCl in it and boiled to expel CO_2. Cooled and 200ml distilled water was added to dissolve the contents. It was transferred to a one liter volumetric flask and made up the volume. Stored in a glass reagent bottle
2. Standard solution of EDTA (0.01N): 2g of EDTA-di-sodium salt was dissolved in sufficient volume of distilled water in a 400ml beaker and was transferred to one liter volumetric flask. To this, 0.05g of $MgCl_2.6H_2O$ was added and made up the volume to one liter. The normality of this solution was standardized as under.
3. Standardization of EDTA solution: 5ml of standard calcium solution (0.01N) was pipetted in 100ml china dish. It was diluted to 10ml with distilled water. Ten drops each of NaCN and hydroxylamine hydrochloride solutions were added. Then 2.5ml of NaOH solution and 10-15 drops of calcon indicator were added. Pink colour

appeared. In another china dish, a blank solution was prepared in the same manner, taking 5ml of distilled water instead of the standard calcium solution. The blank solution was blue in colour or it turned blue with the addition of 2-3 drops of EDTA solution. This blue blank was kept alongside for comparing the end point. Then a china dish containing the pink colored standard calcium solution was placed on a magnetic stirrer plate. A glass coated iron needle was put in it and stirred. Solution was titrated with EDTA until the colour of the solution changed from pink to blue matching the blank. The volume of EDTA used was noted. Based on calculation, N1V1 = N2V2, necessary dilutions were made so that the normality of the EDTA solution was exactly equal to 0.01 N.

4. Calcon indicator solution (0.5%): 0.5g of calcon reagent (Solochrome dark blue and Eriochrome blue-black R) was dissolved in 100ml 95% ethanol, stored in a plastic bottle.
5. Sodium hydroxide solution (16% or 4 N)
6. Sodium cyanide solution (2%)
7. Hydroxylamine hydrochloride solution (5%)

Procedure: 5ml of digested sample was added in a 100ml china dish and diluted to 10ml with distilled water. To these 10 drops each of 2% NaCN and 5% hydroxylamine hydrochloride solution, 2.5ml of 4N NaOH solution and 10-15 drops of calcon indicator were added. Pink colour appeared. In another china dish, a blank solution was prepared exactly the same manner by taking 5ml of distilled water instead of the test solution. In blank blue colour appeared, if not, 2-3 drops of EDTA solution were added and this blue blank was used for comparing the endpoint of the test solution. Test solution was placed on a magnetic stirrer top and a glass coated iron needle was placed in it and stirred. The solution was titrated with 0.01 N EDTA till the pink colour changed to blue matching the blank.

Calculations

$$\text{Ca (mg per 100g)} = \frac{\text{Vol. (ml) of EDTA used} \times \text{Normality of EDTA} \times \text{Dilution factor} \times 100}{\text{Vol. (ml) of aliquot taken for titration}}$$

Dietary Fibre

Total, soluble and insoluble dietary fibre constituents were determined by the enzymatic method given by Furda (1981) [20]. The sum of insoluble dietary fibre and soluble dietary fibre contents were calculated for determining total dietary fibre content.

Total dietary fibre = Insoluble dietary fibre + Soluble dietary fibre

Insoluble dietary fibre

Reagents

1. 0.005 N HCl
2. Phosphate buffer (pH 10)
3. EDTA
4. Enzymes: Alpha amylase and protease enzymes
5. Ethanol (75% and absolute)
6. Acetone

Procedure

1. Sample preparation: Five gram samples of less than 1mm particle size food material was defatted on a Soxhlet apparatus.
2. Extraction of water-soluble material: The prepared sample weighing about 2.0g was dispensed in 200ml of 0.005N HCl and boiled for 20 minutes. The suspension was then cooled down to 60°C; 0.3g of disodium EDTA was added and then adjusted to pH 5.0-6.5 with 12ml of phosphate buffer pH 10. The extraction was continued for an additional 40 min at 60ºC to ensure the extraction of pectin with minimal degradation.
3. Starch and protein hydrolysis: pH was adjusted 6.0-6.5 to bring the solution closer to the pH optimum of amylase and protease. Suspension was cooled to 20-30ºC before incubation overnight with 10mg of bacterial alpha-amylase and 10mg of bacterial protease. The incubation was continued by slow stirring with a magnetic bar.
4. Isolation of insoluble dietary fibre: The suspension was filtered through a coarse – tarred gooch filtering crucible containing glass wool and the insoluble residue was washed with a small amount of water. The filtrate was saved for the next step.
5. The insoluble residue was then washed with water, alcohol and acetone before being dried at 70°C in a vacuum oven overnight. The dry residue constitutes insoluble dietary fibre.

Soluble dietary fibre

Precipitation and isolation of soluble dietary fibre

The saved filtrate was acidified with a few drops of concentrated hydrochloric acid to pH 2-3; this pH tended to enhance the rapid precipitation of polysaccharides. Four volumes of ethanol were slowly added and left suspended to stand for about 1 h. Filtered the precipitate on a tarred, coarse gooch crucible containing glass wool, then washed with 75% ethanol, absolute ethanol, and acetone before drying at 70°C in a vacuum oven overnight. The residue was weighed in the crucible to give the soluble dietary fibre content of the original material. The soluble dietary fibre fraction was corrected for ash and for co-precipitated protein.

Total dietary fibre (TDF): the sum of insoluble dietary fibre was calculated.

TDF = Insoluble dietary fibre + soluble dietary fibre

Antinutritional factors

Samples of different cereal flour like barley, oat, sorghum & chickpea were analyzed for Anti nutrition factor: Phytic acid, Polyphenols

Phytic acid

Phytic acid was determined by the method of Haugh & Lantzsch (1983) [23].

Reagents

1. Phytate reference solution: Exactly 30.54mg sodium phytate (5.5% water, purity and containing 12 Na/mole) was dissolved in 100ml of 0.2 N HCl, which gave a solution containing 200 µg phytic acids per/ml.
2. Ferric ammonium sulphate solution: Ferric ammonium sulphate (0.2g) was dissolved in 100ml of 2N HCl and made the volume of 1000ml with distilled water.
3. Bipyridine solution: Ten gram 2-2 bipyridine and 10ml thioglycolic acid were dissolved in distilled water and volume was made to 1000ml.

These solutions are stable for several months at room temperature.

Extraction
A fine ground sample (0.5g) was extracted with 25ml of 0.2 N HCl for 3 hours continuous shaking in a shaker. Thereafter, it was filtered through Whatman # 1 filter paper.

Estimation
An aliquot (0.5ml) of the above extract was pipetted into a test tube fitted with a round glass stopper. One ml of ferric ammonium sulphate was added. The tube was heated in a boiling water bath for 30 minutes. The contents of the tube were mixed and centrifuged at 3,000 rpm for 30 minutes. One ml of supernatant was transferred to another test tube and 1.5ml bipyridine solution was added. The absorbance was measured at 519 nm against distilled water. For plotting a standard curve, different concentrations (0.2 to 1.0ml) of standard sodium phytate solution containing 40-200 µg phytic acid were taken and made to 1.4ml with water O.D. of 0.342 corresponded to 80µg phytic acid.

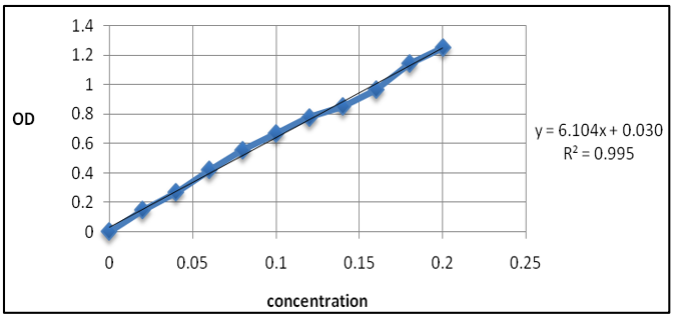

Fig 1: Standard curve of phytic acid

Polyphenols
Total polyphenols were extracted by the method of Singh & Jambunathan (1981) [47]. Defatted sample (500mg) was recirculated with 50ml methanol containing 1% HCl for four hours. The extract was concentrated by evaporating on a hot water bath and brought the final volume to 25ml with methanolic-HCl. The amount of polyphenolic compounds was estimated as tannic acid equivalent according to Folin-Davis procedure (Swain & Hillis, 1959) [50].

Reagents
1. Folin-Denis reagent: To 750ml water, 100g sodium tungstate, 20g phosphomolybdic acid and 50ml phosphoric acid were added, and heated and then refluxed for 2 hours. It was cooled and diluted to one liter.
2. Tannic acid (stock solution): 100mg of tannic acid was dissolved in water and made up to one liter. In order to have a working standard solution, 20ml stock solution was further diluted to 100ml with water.
3. Saturated aqueous sodium carbonate solution: Dissolved 350g sodium carbonate in one liter hot distilled water at 70 ºC to 80 ºC, cooled and filtered through glass wool.

Procedure
Test solution (1.5ml) was diluted with distilled water upto 8.5ml in a graduated test tube. After thoroughly mixing, Folin-Denis reagent was added 0.5ml and the tubes were well shaken. Exactly after 3 minutes, one ml of saturated sodium carbonate, solution was added and the tubes were thoroughly shaken again. After an hour, the absorbance was read at 725nm on UV-VIS Spectrophotometer, using a suitable blank. If the solution was cloudy or precipitates appeared, it was centrifuged before readings were taken. A standard curve was plotted by taking 0.5ml to 4.0ml working tannic standard solution containing 10 to 80µg tannic acid.
Where,

$$\text{Polyphenols (mg/100g)} = \frac{M \times V \times 100}{W \times V_1 \times 1000}$$

M = Concentration of extract elute obtained from graph
V = Volume made of extract (ml)
W = Weight (g) of the sample
V_1 = Volume of extract aliquot taken (ml)

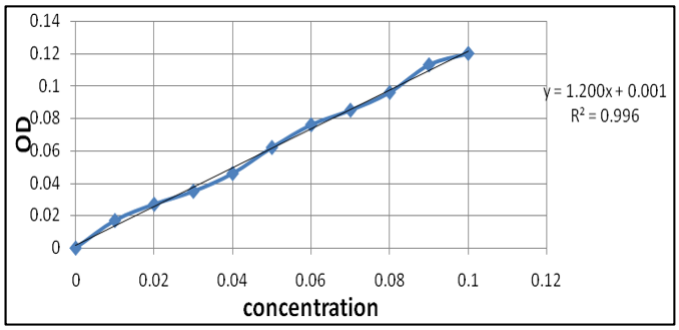

Fig 2: Standard curve for polyphenol

Total phenolic content (TPC)
The TPC in raw and cooked foods was determined according to the method of Singleton and Rossi, (1965) [48] and modified by Saucier & Waterhouse (1999). The results were expressed in gallic acid equivalent (GAE) mg/100gm of fresh weight.

Sample Preparation
The food samples were first homogenized using mortar and pestle. The 5gm of sample was taken in a test tube for extraction overnight with 20ml of 80% methanol for raw foods and 100% methanol for cooked foods. The test tube was vortexed for two minutes and kept for overnight extraction. After the overnight extraction, the test tube was centrifuged for 10-15 min at 2000 rpm. The supernatant obtained, after centrifugation, was used for the analysis of TPC.

Reagents
1. Gallic acid (GA) standard solution (100mg) Stock solution: 100mg gallic acid dissolved in 100ml distilled water (D/W) Working solution: took 1ml stock and volume made up 100ml with D/W
2. Folin-Ciocalteu (FC) reagent (50%): 1:1 dilution with D/W
3. Sodium carbonate (7.5%): Dissolved 7.5g Na_2CO_2 in 100ml D/W

Procedure
For each analysis, six replicates were taken and more than 1.5ml of water was pipette into each test tube. A 20µl sample solution and 20 µl of water was pipette into standard, sample and blank test tubes and mixed thoroughly. For standard solution, 1mg of gallic acid was dissolved in 1ml of distilled water. Different aliquots (2, 4, 6, 8, 10, 12, 14, 16, 18 and

20µl) were taken for obtaining standard graphs. The standard solution was freshly prepared each time. The 100 µl of FC-reagent was added to each test tube and the solutions were mixed again. A 300 µl of a 20% sodium carbonate (Na_2CO_3) solution was added to each test tube after 30 see and before 8 min. The solution was left at room temperature for 2 hr. Then the absorbency of the developed blue color was determined at 700 nm with the help of spectrophotometer. The amount of light absorbed is proportional to the amount of oxidizable material present, *viz*, phenolic compounds. For control, methanol is used in the place of extract.

Antioxidant activity (%)

Antioxidant activity was measured using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) dye as per the procedure described by Shimada *et al*. (1992) [45].

Preparation of dye

25mg DPPH dye was weighed and 10ml of methanol was added to it with vigorous shaking until the dye got dissolved. One ml of this solution was then made up to a volume of 100ml in a volumetric flask (working solution).

Extraction

500mg of sample were macerated in 10ml methanol and centrifuged at 4000 rpm. The supernatant was used to measure antioxidant activity.

Estimation

Three ml of dye working solution was mixed with 0.5ml of supernatant and incubated for 30 minutes at 25 to 30˚C in water bath and absorbance was measured with spectrophotometer at 517 nm. Dye mixed with methanol was used as a blank. Lower absorbance of reaction mixture indicated higher free radical scavenging activity.

$$\text{Antioxidant activity (\% scavenging of DPPH)} = \frac{A_0 - A_1}{A_0} \times 100$$

Where,

A_0 = absorbance of blank

A_1 = absorbance of sample

Preparation of multigrain high protein fibre enriched composite bars

In order to improve the nutritional quality, multigrain bars were developed by using oat, barley, sorghum, chickpea and groundnut, composite bars, *i.e.* fibre and protein rich bars were prepared. Fibre rich bars were prepared by addition of rolled oat, carrot powder and psyllium husk whereas protein rich was supplemented with the help of groundnut, whey protein isolate/ soy protein isolate. Bar was standardized using different levels of cane sugar, honey and jaggery addition with binding agent (gum acacia). However, other required ingredients are to be kept constant in all three types of bars. Organoleptic evaluation of different types of composite bars with control samples was carried out. A preliminary trial was conducted to standardize the quantity of different ingredients required for the preparation of bars.

Standardization of ingredients for bars

The main ingredient for the preparation of bars was cereal flakes and completely roasted or popped grains. The cereal grains were used at a level of 30 to 40% in different treatments. Dried fruits like dehydrated mango chunks, raisins and nuts like peanuts and cashew nuts were used up to 10%. For enriching the bars, carrot powder, bottle gourd powder, psyllium husk, whey protein concentrate, and soya protein concentrate are used. The standardized quantity of different ingredients used for the preparation of 100g of composite bars using jaggery, honey and cane sugar are furnished in table 1 and 2, respectively.

Table 1: List of ingredients used for optimization of composite bars

Cereal grain and pulses	**Oat, barley, sorghum, chickpea, maize, finger millet, rice (puffed), amaranth**
Nuts and oil seeds	groundnut, flaxseed and sesame seed
Functional & fibre source	Psyllium husk, carrot, bottle gourd, pumpkin, banana, mango, kinnow peel, lemon peel
Sugar source	Cane sugar, honey and jaggery
Protein source	Whey protein concentrate / soy protein isolate / soy protein concentrate.

Procedure for preparation of composite bars

All the raw materials were pre preprocessed (dry ingredients) roasted for 1-2 min. Than mixing of ingredients was done with thick syrup (either sugar, honey or jiggery). Immediate mixing of dry ingredients when syrup is still hot with binding agent with continuous stirring. Then immediately pour hot mixture into buttered molder tray with light pressing. Then the tray were Cool down and cutting was done in desired shapes. Packaging in polypropylene, aluminium laminated foil metalized polyester was done. Than all the bars were store at ambient temperature

Table 2: Composition of ingredients in high fibre and high protein enriched composite bars (g/100g)

Ingredients	**High fibre composite bar 1 (CB1)**	**High fibre composite bar 2 (CB2)**	**High fibre composite bar 3 (CB3)**	**High Protein composite bar 4 (CB4)**	**High Protein composite bar 5 (CB5)**	**High Protein composite bar 6 (CB6)**
Puffed rice	10	-	-	10	-	-
Maize flakes	-	10	-	-	10	-
Puffed amaranth	-	-	10	-	-	10
Oat	10	10	10	10	10	10
Chickpea	14	14	14	14	14	14
Groundnut	14	14	-	14	14	-
Sesame seed	-	-	14	-	-	14
Fruit and veg. candy	4	4	4	4	4	4
Carrot powder	6	6	6	-	-	-
Whey protein isolate	-	-	-	6	6	6
Jaggery	40	40	40	40	40	40
Gum acacia	2	2	2	2	2	2
Total	100	100	100	100	100	100

Results and Discussion

Proximate composition of various candies, chunks & powders

Nutritional composition of candies, chunks, and powders is presented in table 3. The results pointed out that the highest level of moisture content was observed in pumpkin candy (16.28g) whereas least moisture content was observed in bottle gourd powder (3g/100g). Significantly, a higher amount of protein content was found in bottle gourd powder (7.17g/100g) than in carrot powder. Lesser amount of protein (0.09g/100g) content was reported in kinnow peel candy. The results pointed out that the highest level of moisture content was observed in pumpkin candy (16.28g/100g) whereas least moisture content was observed in bottle gourd powder (5g/100g). Similar results for moisture content of lemon and kinnow peel candy were reported by Nehra (2011) [35]. Higher value was observed by Mahmoud *et al.* (2015) [31] for air oven dried citrus peel (7.83 to 9.99g/100g). Significantly, a higher amount of protein content was found in bottle gourd powder (7.17g/100g) than in carrot powder. Similar results were observed for protein content for lemon and kinnow peel candy by Nehra (2011) [35]. Higher moisture content was reported by Ghazali *et al.* (2013) [21], whereas similar value for protein content was observed. Lower moisture content for both carrot (1.8%) and bottle gourd pomace powder (3.5%), also very low amount of protein was observed for bottle gourd pomace powder (0.13%) and carrot pomace powder (0.96%) by Vandana (2008) [52]. Madan & Dhawan, (2005) [30] showed that carrot candy prepared with sugar syrup had moisture content values of 16.20%. Carrot powder exhibited a higher amount of crude fat (1.42g/100g) whereas least amount of fat was observed in lemon peel candy (0.07g/100g). Least ash content was observed in lemon peel candy (0.28g/100g) while carrot powder showed a significantly higher amount of ash content. Bottle Gourd powder also exhibited a high amount of ash content (2.31g/100g) after carrot powder. The results pointed out that carrot powder and bottle gourd powder contain higher amounts of fibre (22.40g/100g and 20.29g/100g) whereas lowest amount of fibre was found in lemon peel candy (0.27g/100g). Lower fat content reported by Ghazali *et al.* (2013) [21]. Vandana (2008) [52] observed ash content in bottle gourd powder (2.5g/100g) similar to present study and for carrot pomace powder higher ash content was observed (4.3g/100g) than the present study. Higher protein content was observed for carrot powder by Chantaro (2008) [9], *i.e.* 9.75g/100g and Ghazali *et al.* (2013) [21] reported 6.16g/100g, whereas fat content was reported similar in line by Chantaro (2008) [9], on other hand higher fat content 2.43g/100g for carrot powder was reported by Ghazali *et al.* (2013) [21]. Lemon peel candy was observed with higher carbohydrate content (99.20g) and energy (398.14 kcal). However, the lowest carbohydrate content (69.29g) and energy (315.16 kcal) was discovered in carrot powder. Bansal (2018) [6] noticed the nutritional composition of carrot powder and reported moisture in carrot powder (2.55g/100g), crude protein (1.22g/100g), fat (1.37g/100g) ash (1.89g/100g) and fibre (2.11g/100g). Nutritional composition of carrot powder was analyzed by Jalgaonkar *et al.* (2018) [24]. They found higher values for moisture 10.92%, ash 1.37%, and protein 7.13% and lower value for fat 0.80%. Vandana (2008) [52] reported that bottle gourd pomace powder and carrot pomace powder contained 3.5g/100g and 1.8g/100g moisture, 0.13 and 0.96g/100g protein, 0.51 and 0.53g/100g fat, 2.5 and 4.3g/100g ash, 24.1 and 17.7g/100g crude fibre, 72.7 and 75.2g/100g carbohydrate, respectively. Kulshrestha (2004) [26] noticed higher moisture content (7.51g/100g), protein (12.69g/100g), ash (2.69g/100g), similar values for fat (1.39g/100g), carbohydrate (68.30g/100g) and energy (336 kcal/100g) in carrot powder. Muzzaffar *et al.* (2016) [33] noticed that pumpkin candy contains moisture content (20.1g/100g), ash (1.25g/100g) and fibre (0.65g/100g), which was similar to present study except high moisture. Mango contains nearly 81% moisture, 0.4% fat, 0.6% protein, 0.8% of fibres and 17% of carbohydrates (Bommy & Maheswari, 2016) [8]. Naz *et al.* (2014) [34] studied eight varieties of mangoes and observed maximum moisture and ash contents in mango pulp of Fajri & Sindhri varities (92.20% and 0.78%). Ubwa *et al.* (2014) [51] assessed proximate composition for three varieties of mango *viz.* 'Hindi mango', 'Julie mango' and local mango', and reported the moisture content varied from (78.41% to 82.22%), protein (1.38 to 1.30g/100g), crude fat (0.16 to 0.072g/100g), carbohydrates (19.60 to 16.25g/100g), vitamin C (7.24 to 6.04g/100g), ash (0.45 to 0.31g/100g) and crude fibre (0.84 to 0.94g/100g). Muzzaffar *et al.* (2016) [33] reported the similar ash and fibre content in pumpkin candy. Kumari & Grewal (2007) [27] have reported that carrot pomace on dry weight basis contains 2.5% moisture, 5.5% ash, 1.3% fat, 0.04% protein, 20.9% crude fibre, 55.8% total dietary fibre, 71.6% total carbohydrate and 301 kcal/100g energy.

Table 3: Proximate composition of various candies, chunk and powders

Sample	Moisture (g/100g)	Crude Protein (g/100g)	Crude Fat (g/100g)	Ash (g/100g)	Crude Fibre (g/100g)	Carbohydrate (g/100g)	Energy (kcal)
Lemon peel candy	12.66±0.76	0.18±0.00	0.07±0.01	0.28±0.02	0.27±0.03	99.20	398.14
Kinnow peel candy	11.96±0.68	0.09±0.00	0.10±0.01	0.32±0.03	0.35±0.02	99.12	397.81
Carrot candy	12.93±1.25	0.55±0.05	0.09±0.00	0.80±0.02	0.54±0.02	98.01	395.11
Pumpkin candy	16.28±0.20	0.58±0.03	0.91±0.09	0.65±0.18	0.64±.006	97.21	399.36
Mango chunks	08.92±0.08	0.75±0.04	0.63±0.05	1.51±0.05	0.60±0.06	96.50	394.68
Carrot powder	03.70±0.29	6.30±0.24	1.42±0.09	2.38±0.06	22.40±0.05	69.29	315.16
Bottle Gourd powder	03.00±0.02	7.17±0.30	1.14±0.10	2.31±0.03	20.29±0.03	69.46	328.78
CD at 5%	1.094	0.266	0.117	0.140	0.908		

Value are mean + SD of three observations

Mineral content and dietary fibre in candies, chunk, and powders

The mineral content of various fruits and vegetable candies (lemon peel, kinnow peel, carrot, and pumpkin), chunks of mango and powders of carrot and bottle gourd, depicted in table 4. Results revealed that the calcium content was found highest in carrot powder (45.20mg/100g) followed by pumpkin candy (36.26mg/100g), carrot candy

(26.10mg/100g) while, the bottle gourd powder showed the highest iron (5.64mg/100g) and zinc (3.56mg/100g) content respectively. Calcium (2.67mg/100g) and iron (0.18mg/100g) content was observed lowest in lemon peel candy. While, the zinc content was observed minimum in kinnow peel candy (0.05mg/100g). Bansal (2018) [6] noticed mineral composition of carrot powder, and his findings showed that calcium (82.43mg/100g) was significantly higher than the observed value in present study, whereas similar value of iron content (2.50mg/100g) and lower value of zinc content (1.13mg/100g) were exhibited. Jalgaonkar *et al.* (2018) [24] reported higher moisture content, whereas lower fat, ash content and similar protein content. Higher calcium content (291.20mg/100g) and iron (11.66mg/100g) in carrot powder was estimated by Shyamala *et al.* (2010) [46]. Vandana (2008) [52] assessed mineral content of bottle gourd and carrot pomace powder and reported that bottle gourd pomace and carrot pomace powder contained 1.9mg/100g and 0.65mg/100g of iron, 1.5mg/100g and 0.91mg /100g of zinc respectively. Kulshrestha (2004) [26] reported higher calcium content and iron content for carrot powder, whereas zinc content was in line with the present study. Jalgaonkar *et al.* (2018) [24] noticed higher value for mineral content of carrot powder for calcium, iron and zinc. Mahmoud *et al.* (2015) [31] revealed mineral content in citrus peel, *i.e.* calcium 158.21mg/100g, Fe 34.32mg/100g and zinc content 6.38 - 8.22mg/100g. They also observed that drying method affects the mineral content available in citrus peel. Dietary fibre of various processed products of fruits and vegetables isalso depicted in table 4. All the samples were analyzed for total soluble and insoluble fibre. Maximum values of total soluble fibre (6.01mg/100g) and insoluble fibre (17.02mg/100g) were observed in bottle gourd and carrot powder, respectively. Results revealed that both total soluble and insoluble fibre content were lowest for mango chunks (0.32mg/100g) and (1.02mg/100g) respectively. All the samples were analyzed for total soluble and insoluble fibre, these fibres lay an important role in human health (Anderson *et al.* 1994) [5]. Maximum values of total soluble fibres were found in bottle gourd (6.01mg/100g) whereas insoluble fibre was found maximum in carrot powder (17.02mg/100g), respectively. Results revealed that both total soluble and insoluble fibre content was found lowest for Mango chunks (0.32mg/100g) and (1.02mg/100g). Vandana (2008) [52] reported high dietary fibre in carrot (48.3mg/100g) and bottle gourd pomace powder (59.0mg/100g).

Table 4: Mineral composition and dietary fibre (mg/100g) in candies, chunk and powders

Sample	Calcium	Iron	Zinc	Total soluble	Total Insoluble
Lemon peel candy	02.67±0.05	0.18±0.01	0.15±0.00	1.56±0.02	3.72±0.04
Kinnow peel candy	02.81±0.03	0.30±0.02	0.05±0.00	1.62±0.06	3.25±.0.01
Carrot candy	26.10±0.75	2.07±0.19	0.67±0.15	3.56±0.05	6.82±0.05
Pumpkin candy	36.26±0.45	0.39±0.01	0.20±0.00	0.81±0.01	2.20±0.08
Mango chunks	08.53±0.03	0.95±0.04	0.15±0.00	0.32±0.02	1.02±0.01
Carrot powder	45.20±0.40	2.35±0.06	2.57±0.07	2.05±0.02	17.02±0.03
Bottle Gourd powder	11.66±0.30	5.64±0.09	3.56±0.04	6.01±0.01	15.21±0.01
CD at 5%	0.679	0.155	0.118	0.042	0.159

Value are mean + SD of three observations

Bao & Chang (1994) [7] reported high dietary fibre in carrot pulp, *i.e.* soluble dietary fibre (8.9mg/100g), and insoluble dietary fibre (28.6mg/100g). Kulshrestha (2004) [26] reported similar results for carrot powder dietary fibre. Figuerola *et al.* (2005) noticed dietary fibre content in lime peel (66.7-70.4mg/100g), orange peel (64.3mg/100g) and lemon peel (60.1- 68.3mg/100g). Kumari & Grewal (2007) [27] reported that carrot pomace on a dry weight basis contains 0.23% total carbohydrate and 301±0.09 kcal/100g energy.

Bioactive components present in candies, chunks, and powder

The bioactive components present in various fruits and vegetables candies prepared from lemon peel, kinnow peel, and carrot, pumpkin candies, chunks of mango, powders of carrot and bottle gourd is depicted in table 5. All the above stated samples analyzed for phytic acid, tannins, total phenolic, and antioxidant activity. The maximum and minimum phytic acid content was found in carrot powder (63.80mg/100g) followed by pumpkin candy (26.56mg/100g). Phytic acid present in lemon peel candy (45.60mg/100g), kinnow peel candy (42.46mg/100g), mango chunks (50.55mg/100g) and bottle gourd powder (48.10mg/100g), respectively. Bansal (2018) [6] estimated higher phytic acid and polyphenols of carrot powder such as 125.48mg/100g and 147.43mg/100g than the present study. The maximum and minimum phytic acid content was found in carrot powder (63.10mg/100g) and pumpkin candy (26.56mg/100g), respectively. Phytic acid present in other candies chunks and powders, lemon peel candy (45.60mg/100g), kinnow peel candy (42.46mg/100g), mango chunks (50.55mg/100g) and bottle gourd powder (48.10mg/100g). Shyamala *et al.* (2010) [46] reported similar result phytate content of carrot pulp 61.53mg/100g. Jalgaonkar *et al.* (2018) [24] found antioxidant activity of carrot powder (29.52mg/100g) and total phenol content (170.50mg/100g). Highest values of tannins (27.99mg/100g), total phenolic (34.61mg/100g), and antioxidant activity (86.38%) observed in lemon peel candy. Tannins were observed lowest in carrot candy (0.20mg/100g), while total phenolic (13.26mg/100g) and antioxidant activity (32.45%) were lowest in bottle gourd powder. Tannins were found in kinnow peel candy (23.29mg/100g), pumpkin candy (0.22mg/100g), mango chunk (2.90mg/100g), carrot powder (10.85mg/100g) and bottle gourd powder (10.20mg/100g) respectively. Whereas total phenolic content is present in kinnow peel candy (30.82mg/100g), carrot candy (32.56mg/100g), pumpkin candy (18.20mg/100g), mango chunk (31.42mg/100g), carrot powder (27.20mg/100g) and bottle gourd powder (13.26mg/100g) respectively. Jalgaonkar *et al.* (2018) [24] reported total phenol content (170.50%) of carrot powder and antioxidant activity (29.52%) lower than the values reported in the present study. Kapoor (2011) [25] observed tannins, total phenol content and scavenging activity (antioxidant activity) for carrot candy and found the values of

0.59mg/100g, 93.68mg/100g and 74.37% respectively. Similar antioxidant activity was shown by Kapoor (2011) [25] for carrot candy. High value of antioxidant activity of lemon peel candy, kinnow peel candy and carrot candy may be due to higher phenolic content. Muzzaffar *et al.* (2016) [33] reported similar results for antioxidant activity of pumpkin candy. Pumpkin can be utilized into commercial products like jam, pickle, beverages, candy, seed oil, bakery and confectionery products (Dhiman *et al.* 2007) [18]. Antioxidant activity of bottle gourd powder (31.0mg/ml) and total phenolic content (11.9mg/100g) was reported by Agrawal *et al.* (2015) [4]. Rafiq *et al.* (2018) [40] reviewed the citrus peel functional properties and concluded that citrus peel can be used as a potential antioxidant instead of synthetic one due to high phenolic components. Ramful *et al.* (2010) [41] shows the data on total phenol content of peel (flavedo + albedo) extracts of citrus fruits measured by the Folin-Ciocalteu assay and observed that phenolic content in many citrus fruits peel like lemon (1900 µg/g), grapefruit (1550 µg/g), oranges (736 µg/g). Harshita (2015) [22] recorded the total phenols (44.23mg/100g) in mango Safeda. Antioxidant activity was found maximum in lemon peel candy followed (86.38%) by kinnow peel candy (83.92%), carrot candy (75.34%), mango chunks (74.56%) and carrot powder (52.50%). Bottle gourd powder and pumpkin candy exhibited the least amount of antioxidant activity (32.45% and 33.50%). Deore *et al.* 2009 [17] reported the antioxidant activity of bottle gourd powder, the percentage inhibition of concentration 20, 40 and 60mg/ml were about 79.12, 87.34 and 91.23% respectively. Muzzaffar *et al.* (2016) [33] reported the antioxidant activity (34.31%) and total phenol content 40.16mg/100g of pumpkin candy, as similar in case of antioxidant activity.

Table 5: Bioactive components present in candies, chunk and powders

Sample	Phytic acid (mg/100gm)	Tannins (mg/100gm) (TAE)	Total Phenolics Content mg/100gm (GAE)	Antioxidant Activity (%)
Lemon peel candy	45.60±0.01	27.99±0.02	34.61±0.02	86.38
Kinnow peel candy	42.46±0.02	23.29±0.02	30.82±0.02	83.92
Carrot candy	47.20±0.01	0.20 ±0.01	32.56±0.06	75.34
Pumpkin candy	26.56±0.10	0.22±0.0.3	18.20±0.01	33.50
Mango chunks	50.55±0.05	2.90±0.01	31.42±0.05	74.56
Carrot powder	63.80±0.02	10.85±0.03	27.20±0.04	52.50
Bottle gourd powder	48.10±0.05	10.20±0.02	13.26±0.02	32.45
CD at 5%	0.428	0.272	0.175	0.374

Value are mean + SD of three observations

Functional properties of candies, chunks, and powders

The functional properties of various processed products of fruits and vegetables including lemon peel, kinnow peel, carrot, pumpkin candies, chunks of mango, powders of carrot and bottle gourd is presented in table 6. All the previously mentioned samples were analyzed in order to find the bulk density, water absorption capacity, and swelling power. Results revealed that the bulk density was found maximum for mango chunks (0.37g/ml) and minimum for lemon peel candy (0.31g/ml). However, the water absorption capacity and swelling power showed similar results depicting maximum values for carrot powder (3.96ml /g, 130.8%) and minimum for mango chunks (0.55ml /g, 105.5%). Smita & Karuna (2014) [49] observed water absorption capacity of bottle gourd powder within range (94.3% -126.21%), also the bulk density of bottle gourd powder varied between range of (0.478g/ml - 0.496g/ml). Bulk density of carrot powder 0.515g/cm^3, water-holding capacity 5.425g/g, and swelling capacity 11.25 was reported by Sahni & Shere (2017) [43].

Table 6: Functional properties of candies, chunks and powders

Sample	Bulk density (g/ml)	Water absorption capacity (ml/g)	Swelling power (%)
Lemon peel candy	0.31±0.01	0.73±0.02	113.1±0.35
Kinnow peel candy	0.34±0.01	0.75±0.01	111.2±0.87
Carrot candy	0.34±0.04	0.64±0.02	109.2±0.21
Pumpkin candy	0.33±0.02	0.69±0.01	111.2±0.80
Mango chunks	0.37±0.01	0.55±0.01	105.5±0.11
Carrot powder	0.35±0.01	3.96±0.07	130.8±1.40
Bottle gourd powder	0.34±0.02	3.62±0.05	127.0±1.06
CD at 5%	0.017	0.067	1.447

Value are mean + SD of three observations

Sensory evaluation of bar prepared using various levels of powder from carrot, bottle gourd & Psyllium husk

The sensory evaluation of bar prepared using various levels of powder from carrot, bottle gourd, & Psyllium husk with puffed rice and jaggery is shown in following figure 3. For fibre enrich samples, four different levels (0, 2, 4, and 6%) of each carrot powder, bottle gourd powder and psyllium husk were used. Carrot powder was liked upto 6% and psyllium husk incorporated in bars only up to 2%. Carrot powder was liked most by the sensory panel. Maximum sensory score was observed for carrot powder (8.31) at 6% concentration as shown in figure 3.

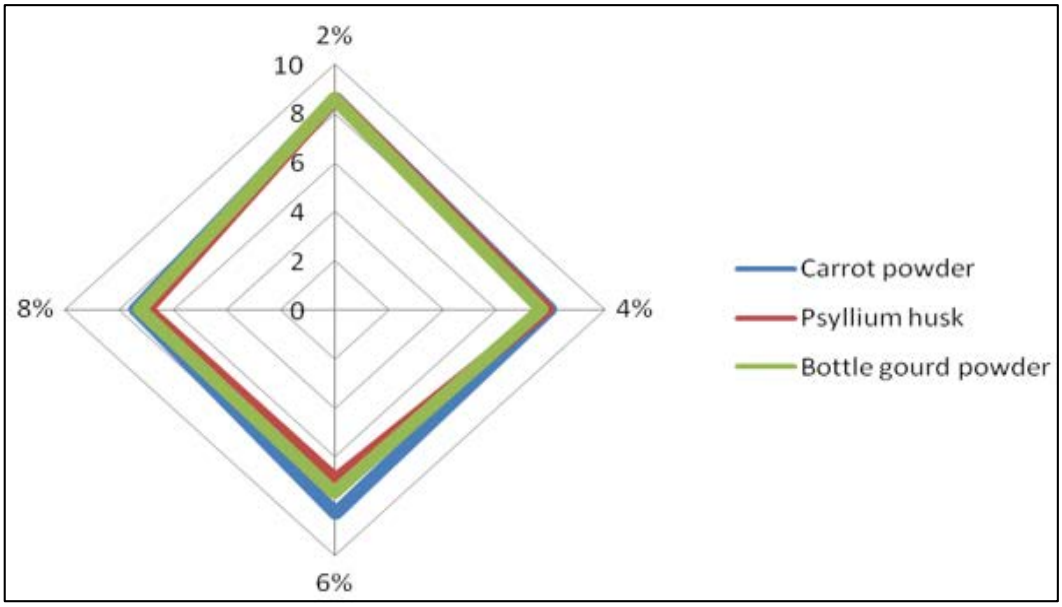

Fig 3: Sensory evaluation of bar prepared using various levels of powders

Standardization of composite bars is a tryout process where a product is tested a number of times until the desired final product is obtained (Quadri & Rao, 2018) [39]. Ravindra & Sunil (2018) [42] developed and evaluated the puffed cereal bar with 38g of jaggery, similar to present study with 40% jaggery level in bar, all the samples were adjudged "liked very much" Organoleptically. Bars were made based on the combinations and other ingredients like jaggery, binding agent, oats flakes, rice flakes etc. were kept constant and bars developed. All the processed ingredients were added to jaggery syrup, spread on a tray, cooled and cut to bars of required size. Samakradhamrongthai *et al*. (2021) [44] prepared high energy cereal bar using the optimum content of cereals, fruits, and sweeteners for HCB was found to be 60.45%, 19.55%, and 20%. Costa *et al.* (2021) [12] reported that the dried tomato and carrot cereal bars were the most accepted and did not differ statistically ($p > 0.05$) for all the attributes.

Sensory evaluation of candies and chunk prepared from fruits, fruit peel, and vegetables

Data of sensory evaluation of candies prepared from fruits, fruit peel and vegetables candy (lemon, kinnow carrot, pumpkin) and chunks of mango is expressed in figure 4. Out of all the samples, maximum overall acceptability was observed in lemon peel candy (8.53) followed by carrot candy (7.87). Both candies were further used in preparation of protein and fibre enriched composite bars. Smita & Karuna (2014) [49] reported that steam blanched bottle gourd powder at 60 ºC was found superior with quality attributes. Phebean *et al.* (2017) [37] reported that carrot powder up to 10% with 15% cowpea powder and 75% wheat flour could be added in preparation of cookies without affecting the sensory properties.

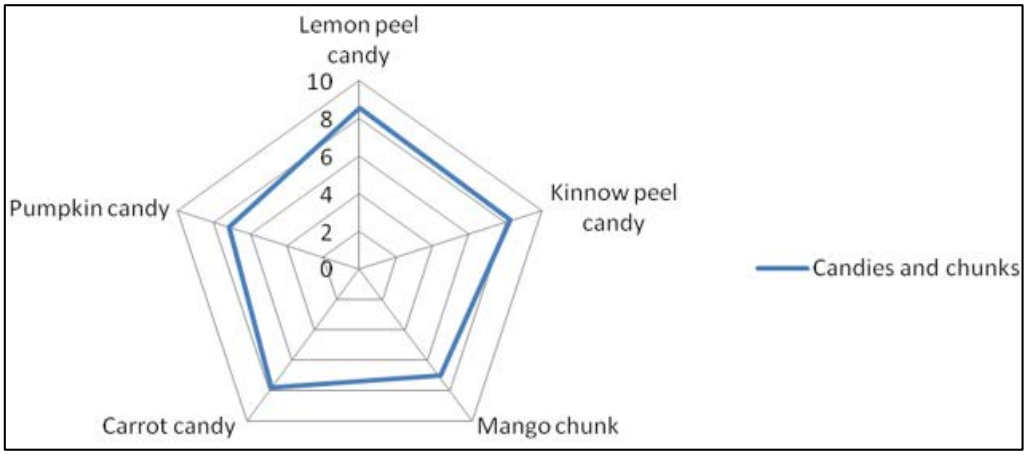

Fig 4: Sensory evaluation of candies and chunk prepared from fruits, fruit peel, and vegetables

Kumari & Grewal (2007) [27] reported that incorporation of carrot powder increased the sensory attributes by the addition of carrot powder upto 20% whereas 30% carrot powder significantly decreased the mean scores for some sensory attributes of sweet biscuits and all the sensory attributes of sweet 'n' salty biscuits. Ferreira *et al.* (2015) [19] formulated and characterized functional foods based on fruit and vegetable residue flour. According to Decker *et al.* (2014) [14], different processing was done for oat grain *viz*. groats, milling, flaking, rolling and flour. de Barros *et al.* (2022) [14] also reported the preparation and sensory evaluation of bars prepared from Murici fruit pulp.

Plate 1: Candies, powders and chunks prepared from fruits and vegetables

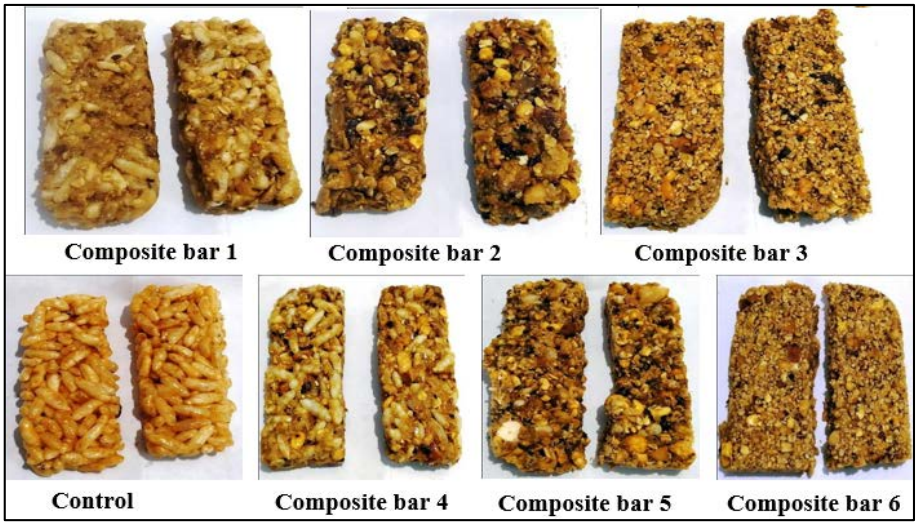

Plate 2: Fibre and protein enriched composite bars prepared from various cereals, pulses, nut and oilseeds

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