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Comparison of the Functional Characteristics of Ready-To Eat Coconut Based Snack

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Abstract: *Several locally available chief sources of roots and spices such as beet root, carrot, ginger and mint have been chosen for the present study for their variable concentrations and compositions in phenolic compounds and other functional characteristics as osmotic infusions in the form of filtrates. Sliced samples (0.8±0.1mm) of matured coconuts (10-12 months old) were subjected to osmotic dehydration for a period from 0 min to 720 min at room temperature. Then the slices were dried in a hot-air oven (HAOD) at temperature 45-60°C for about 6-7 hours and freeze drying (FD) at temperature (-40 to 30°C) for a duration of 14-16 hours. Osmotic medium without the infusion of filtrates of functional ingredients serves as the control. The dehydrated samples were packed in Aluminium foil laminated LDPE pouches with infusion of 100% nitrogen gas composition and stored at ambient temperature till analyzing the functional characteristics. The development of ready-to eat coconut based snack food utilizing the functional filtrates dehydrated under the two drying methods exposed favorable results in functional characteristics and phenolic components. However the snack developed using HAOD revealed to the best inspite marginal increment in functional characteristics observed in FD due to heat sensitive properties.*

Keywords*: Osmotic dehydration, coconuts, functional compounds, impregnation, antioxidants .*

I. Introduction

Osmotic dehydration is a pre-treatment given to solid foods used to improve the nutritional, sensorial and functional properties of food without changing its integrity (1). It partially dehydrates solid foods and instantaneously impregnates it with solutes that modify its functional, structural and nutritional properties (2,3). Incorporation of physiologically active compounds have been taken place during osmotic dehydration process such as minerals, sugars, acids, phenolic compounds and vitamins from plant produce into food tissue without abolishing the initial matrix of the food have already been attempted by many researchers (4). The physiologically active components have been observed in plant foods like greens leafy vegetables, nuts, roots and tubers are essential for a healthy diet in reducing the risk of major degenerative diseases and various ailments (5). Consumption of nuts is inversely related to the prevalence of degenerative and chronic diseases. Among nuts, coconuts (*Cocus nucifera*) play a foremost role in our daily life, possess traditional distinctiveness, acts as a functional food and also own biologically active components thereby enhancing health and well being (6). Among dark green leafy vegetables, *Mentha piperita* (Peppermint) called as hybrid mint has been used as an ancient folk popular remedy. It acts as an excellent gastric stimulant as it has pleasant taste (7). Ginger (*Zingiber officinale*) is one of the most widely used venerable medicinal root herb consists of several bioactive compounds like gingerols, shogaols and curcumin with health promoting characteristics due to its greatest antioxidant activity (8). The red beet roots (*Beta vulgaris*) and carrots *(Daucus carota)* are considered as a wonderful food ingredient and colorant (9) accepted universally due to the presence of red violet betacyanins, yellow betaxanthins and orange carotenoids with tremendous antioxidant powers.

The incorporation of these plant extractions, herbal infusions into the basic foods have been concentrated as pre-treatments in the emerging food processing sectors to obtain healthy nutritious foods with enriched nutraceuticals and functional components which are beneficial in general. The drying methods are followed after pre-treatments of various foods using osmotic agents, blanching methods etc., to obtain nutritious dehydrated foods without any enzymatic deterioration with extended shelf-life.

The present study emphasis on osmotic dehydration of coconut slices with the impregnation of filtrates of functional ingredients such as *Beta vulgaris*, *Daucus carota*, *Zingiber officinale* and *Mentha piperita* followed by assisted drying methods namely hot air oven drying and freeze drying. This paper reports on the functional characteristics and phenolic compounds of the ready-to eat coconut based snack.

II. Materials And Methods

2.1. Selection and pre-processing of raw materials

Fresh and matured good quality coconuts were purchased from Pazhamudir Nilayam, Puducherry prior to each set of experiments for osmotic dehydration. The coconuts were processed which involves selection of matured coconut of 10-12 months old, followed by removal of husk, breaking into 2 halves, separation of endosperm from shell and removal of testa with the help of a knife. Finally the processed coconut pieces were standardised to obtain optimum thickness of slices using slicers.

The pre-processed coconut pieces were sliced into varying thickness from 0.6 mm to 1.0 mm using screw gauge. The sliced coconut pieces were kept in vessel containing water before commencement of experiments to avoid microbial contamination. The sliced coconuts were subjected to steam blanching at 80 to 90^{o}C for 5 minutes duration to inactivate enzymatic actions. Further the pre-processed coconut slices were subjected to osmotic dehydration using sugar as the main osmotic agent, as it is easily available and cost-effective with increased diffusion rate possessing good mass transfer characteristics as reported by Lerici et al., (10).

The experiments were carried out using sugar as a major component in the osmotic medium infused along with filtrates of functional ingredients namely *Beta vulgaris, Daucus carota, Zingiber officinale and Mentha piperita* obtained from Pazhamudir Nilayam, Puducherry. The functional ingredients were subjected to pre-processing steps like washing, peeling, grating, grinding into fine paste and finally filtered to obtain filtrates using 0.08 mm sieve.

The filtrates of functional ingredients have been taken in the range from every 5% addition upto 100% and impregnated with sugar as the osmotic medium (100%). The thickness of coconut slices, sweetness of sugar and concentration of filtrates were taken in three ratios such as 1:1:1, 1:2:2 and 1:3:3 for standardisation purpose.

2.2. Process involved in the formulation of ready-to-eat coconut based snack

The osmotic dehydration of the coconut slices was carried out with or without the impregnation of filtrates of functional ingredients for a period from 0 min to 720 min. The duration of the osmotic dehydration was finalised based on the physico-chemical and physical properties of the samples such as maximum reduction in brix, weight of the osmotic dehydrated slices and the degree of impregnation of functional characteristics.
Hot air drying and freeze-drying were adopted in the present study. The dehydrated coconut samples obtained from both the drying methods were packed in Aluminium Foil Laminated LDPE pouches with the infusion of 100% nitrogen gas composition and stored at ambient temperature (35^{o}C) for further analysis.

2.2.1. Finalized process parameters

After several permutations and combinations, the process parameters were finalized from the above methodology and represented in the ratio 1:2:2. The thickness of coconut slices, sweetness of sugar and concentration of filtrates from the functional ingredients were standardized and arrived with the above ratio for further processing. The sugar infusion and impregnation of filtrates of functional ingredients at 100% concentration gave the coconut based snack with most acceptable taste, texture, crispiness and sweetness, henceforth this proportion was selected finally. Whereas the osmotic dehydration of the coconut slices without the impregnation of filtrates of functional ingredients serves as the control.

2.2.2. Quality analysis of the ready-to-eat coconut based snack

After the finalisation of process parameters and the development of the snack, various quality characteristics have been analysed in terms of functional characteristics and phenolic compounds as per standard reference methods. All analytical determinations were performed in triplicate. Values were expressed as mean ± standard deviation.

2.2.2.1. Functional compounds of the ready-to eat coconut based snack

Consumption of plant foods, composed of bio active components possess a number of biological effects such as antiviral, antibacterial, antiallergic, anti-inflammation, vasodilatory and antithrombotic (11).

2.2.2.1.1. Tannin content

Colorimetric estimation of tannins is based on the measurement of blue colour formed by the reduction of phosphotungsto molybdic acid by tannin like compounds in alkaline solution (12). A known amount of extract was mixed with 5.0 ml of Folin- Denis reagent (FD) and Na_2CO_3 solution and made up to 100 ml, mixed well and absorbance was read at 760 nm after 30 min using spectrophotometer. Total tannin content as expressed as mg tannic acid equivalent /100 g of sample.

2.2.2.1.2. Steroid content

About 5g dried samples were extracted with 250 ml of acetone for 24 hr. For sterol analysis, acetone extracts were used frequently. Gas chromatography was used to separate individual sterols by 1.80-m column, 6 mm id., packed with 5z OV-101 on Anakrom ABS 80- to 90-mesh. The temperature of the column was 250°C and the temperature of flash heater was kept 50°C above that of the column. The temperature of flame ionization detector was 275°C. The carrier gas was Helium at a flow rate of 100 ml/min (13).

2.2.2.1.3. Alkaloid content

The determination of alkaloids by HPLC consisted of mobile phase by dissolving 9.93 g of monobasic potassium phosphate in 730 ml of distilled water. About 270 ml of acetonitrile was mixed and filtered. The liquid chromatograph was equipped with a 235-nm detector and a 4.6-mm × 150-mm column that contains packing L1. The flow rate was about 1.8 ml per minute (13).

2.2.2.1.4. Saponin content

Saponins were extracted according to the method of Huhman et al., (14). The samples were extracted using extraction solvent methanol prepared with a mixture of water and centrifuged 2200 rpm for 20 min at 4°C prior to liquid chromatographic analysis. HPLC separation was achieved using a reverse-phase, C18 column. Samples were eluted with H_2O.

2.2.2.1.5. Total flavonoid content

Flavonoids were extracted according to the methods of Crozier et al., (15). Extraction solvent was prepared with a mixture of alcohol, water, and hydrochloric acid (50:20:8) and the mobile phase constituted a mixture of methanol, water, and phosphoric acid (100:100:1). Standard solution was prepared using Quercetin RS, kaempferol, myricetin, apigenin, luteolin, hesperidin and isorhamnetin by dissolving it in methanol. About 10 g of the sample was extracted using the extraction solvent in a hot water bath for 135 minutes and allowed to cool at ambient temperature. Chromatographic system was equipped with a 270-nm detector and a 4.6-mm × 25-cm column that contains packing L1. The flow rate was about 1.5 ml per minute. The flavonoid in the samples was identified by comparison made between retention times and spectral characteristics of their peaks with standards.

2.2.2.1.6. Total phenol content

The TPP content was determined according tothe procedure of Folin-Ciocalteu method (16) with slight modifications. Food extracts (0.5 ml) or standard solutions prepared with gallic acid were mixed with 2.5 ml of Folin-Ciocalteu's Reagent (FCR-1:10 dilution) and allowed to stand for 8 min at ambient temperature to let for the FCR to react completely with the phenolates. The absorbances were measured at 760 nm using a Cintra 5 UV-Vis Spectrophotometer after incubating at ambient temperature for a period of 2 h. Results were expressed as milligrams of Gallic Acid Equivalents (GAE) per 100 g fresh weights.

2.2.2.1.7. β-carotene content

The samples were extracted after homogenisation of the samples using food processor at laboratory grade. One gram of dry sample was mixed with 1 g of heavy magnesium carbonate, 30 ml acetone and 20g sodium sulphate and extraction of the sample done by bamix blender for 5 minutes. The above obtained mixture was filtered through a filter paper (Whatman No.4). The filtered residue was re-extracted with 30 ml portions of acetone until no residual colour was noted. The filtrates were made to volume with 100 ml volumetric flask based on the concentration of the colour in the sample. The filtered aliquot of the extract was re-filtered using 0.5 mm nylon filter prior to HPLC analysis. All extractions were conducted in a darkroom. The column 250 mm, 4.6 mm 5 µm C_{18} Microsorb column (Waters, Rydalmere, Australia) was used to separate carotenoids. The mobile phase used in the chromatographic system was 95% methanol, 5% tetrahydrofuran with a flow rate of 2.0 ml/min (13).

2.2.2.2. Antioxidant activity (µg $FeSO_4$ equivalents)

The antioxidant power represents the total antioxidant potential of the samples determined by ferric reducing antioxidant power (FRAP) assay according to the procedure of Benzie and Strain (17). FRAP assay is used to measure the change in absorbance at 593 nm, which results in the formation of a blue color compound II -tripyridyltriazine from colourless oxidized Fe III due to the presence of antioxidants which are electrons donators. FRAP reagent was composed of a mixture of 10 vol of 300-mmol/L acetate buffer, pH 3.6, 1 vol of 10-mmol/L TPTZ (2,4,6-tripyridyl-s-triazine) in 40-mmol/L hydrochloric acid and 1 vol of 20-mmol/L ferric chloride.10 vol of 300-mmol/L acetate buffer, pH 3.6, 1 vol of 10-mmol/L TPTZ (2,4,6-tripyridyl-s-triazine) in 40-mmol/L hydrochloric acid and 1 vol of 20-mmol/L ferric chloride. To the freshly prepared FRAP reagent (3

ml), extract (100-mL) was added and thoroughly mixed and reading taken at 593 nm. Standard curve was made using various concentrations (100-1000 mmol/L) of $FeSO_4.7H_2O$.

2.3. Statistical interpretation of the data

The analyses on sensory, physical, chemical, functional, phytochemical and shelf-life characteristics were done using triplicate samples. The data on experimental results were subjected to Analysis of Variance (ANOVA) and differences between means were assessed by LSD and independent sample 't' test using the statistical package SPSS (18 version) to compare the means to determine the most acceptable treatment ($p \leq 0.05$).

III. Results and Discussion

3.1. Tannin content of the ready-to-eat coconut based snack

Table.1. discusses the tannin content of the ready-to-eat coconut based snack. The tannin content of all the impregnated samples subjected to freeze drying (T_2) showed an increment when compared with hot air oven dried (T_1) samples which was statistically significant at $p \leq 0.05$. Among the freeze dried samples, the highest to lowest order of presence of tannin content was observed in the trend T_2C-4.3 < T_2D-3.5 < T_2A- 2.63 <T_2B-2.4 and registered with statistically significant difference at $p \leq 0.05$. On an average 50% reduction in tannin levels was observed in the impregnated samples subjected to hot air oven drying method. The finding of the present study was in accordance to the results of the following studies as described below.

Table.1. Tannin (mg) content of the ready-to-eat coconut based snack

Samples	Osmotic medium	T_1	% gain	T_2	% gain	p-value
Control	ND	1.1±0.40	-	1.9±0.48	-	0.004*
A	8.1	2.4±0.51	29.63	2.63±0.2	32.47	0.002*
B	6.1	2.08±0.4	34.09	2.4±0.21	39.3	0.003*
C	15.67	4.03±0.12	25.71	4.3±0.34	27.44	0.002*
D	9.1	3.01±0.35	33.1	3.5±0.2	38.46	0.001*

All values are means of triplicate determinations± standard deviation (SD), T_1- Hot Air Oven Drying, T_2- Freeze Drying, Sample A-*Mentha piperita*, Sample B-*Zingiber officinale*, Sample C-*Daucus carota* and Sample D-*Beta vulgaris* filtrate impregnated coconut based snack, ND-Not Detected, *Significant at 5% level

Shyamala and Jamuna (18) investigated that higher tannin content was observed in carrot (318 mg/100g) and beetroot pulp wastes (610mg/100g). Tannins provide excellent antioxidant characteristics in scavenging free radicals and reactive oxygen species. This finding was made in conformity with the results of Abascal et al., (19) who stated that oven-drying at higher temperatures resulted in substantial losses of polyphenols, condensed tannins and antioxidant activity. Freeze-drying conserved the highest percentage of condensed tannins from *Sericea lespedeza* when compared with sun-dried, oven-dried and fresh-frozen leaves.

3.2. Steroid content of the ready-to-eat coconut based snack

Table.2. give details on the steroid content of the ready-to-eat coconut based snack. Steroids are the dietary fats required in essential amounts to maintain healthy body with cardio protective functions. Kaur and Kapoor (20) stated that plant sterols are very analogous to cholesterol. The consumption of plant sterols (2g/day) resulted in 9% reduction of LDL-cholesterol in an experimental study.

Table.2. Steroid (mg) content of the ready-to-eat coconut based snack

Samples	Osmotic medium	T_1	% gain	T_2	% gain	p-value
Control	ND	1.2±0.080	-	1.84±0.110	-	0.001*
A	8.3	3.87±0.150	46.62	4.198±0.016	50.58	0.000*
B	4.5	1.94±0.060	43.11	2.934±0.070	65.2	0.000*
C	8.3	3.98±0.220	47.95	4.74±0.060	57.11	0.291^{NS}
D	6.1	3.09±0.1600	50.66	3.79±0.06	62.13	0.336^{NS}

All values are means of triplicate determinations± standard deviation (SD), T_1- Hot Air Oven Drying, T_2- Freeze Drying, Sample A-*Mentha piperita*, Sample B-*Zingiber officinale*, Sample C-*Daucus carota* and Sample D-*Beta vulgaris* filtrate impregnated coconut based snack, ND-Not Detected, NS- Not Significant,*Significant at 5% level

The percent gain of steroids of the impregnated samples subjected to freeze drying was greater when compared to infused samples dehydrated using hot air oven drying. The highest per cent gain of steroids was seen in *Mentha piperita* and *Zingiber officinale* infusion (T_2A-50.58 and T_2B-65.2) respectively, which showed significant difference ($p \leq 0.05$) when compared with hot air oven dried samples. The finding was consistent with the results of Lowell et al., (21) who stated that diverse drying conditions such as air-drying and oven-drying of two Nicotiana varieties lowered the polyphenol and sterol content. A significant decrease in polyphenols was observed in the samples dried at 100 and 140°C, but there was no effect at 60°C.

3.3. Alkaloid content of the ready-to-eat coconut based snack

Table.3. explains the alkaloid content of the ready-to-eat coconut based snack. Alkaloids have varied structures and many demonstrate a range of pharmacological actions including antimicrobial activity (22). On comparison of % gain of alkaloids of the impregnated samples subjected to hot air oven drying and freeze drying, higher concentration of alkaloids was present in sample impregnated with filtrate of *Mentha piperita* dehydrated using freeze drying (54.24) and hot air oven drying (49.15). There was significant difference observed at $p \leq 0.05$ among the impregnated samples subjected to hot air oven drying and freeze drying. Lim and Murtijaya (23) reported that drying followed by pre-processing of plant foods generally results in depletion of natural antioxidants like tannins, alkaloids and polyphenols owing to prolonged thermal applications, as these compounds are relatively unstable.

Table.3. Alkaloid (mg) content of the ready-to-eat coconut based snack

Samples	Osmotic medium	T_1	% gain	T_2	% gain	p-value
Control	ND	1.1±0.10	-	1.22±0.06	-	0.149 ^{NS}
A	7.06	3.47±0.14	49.15	3.83±0.01	54.24	0.001*
B	6.46	3.03±0.08	46.9	3.32±0.01	51.4	0.003*
C	6.75	2.93±0.09	43.41	3.4±0.01	50.37	0.2 ^{NS}
D	6.32	2.68±0.01	42.4	2.83±0.08	44.77	0.001*

All values are means of triplicate determinations± standard deviation (SD), T_1- Hot Air Oven Drying, T_2- Freeze Drying, Sample A-*Mentha piperita*, Sample B-*Zingiber officinale*, Sample C-*Daucus carota* and Sample D-*Beta vulgaris* filtrate impregnated coconut based snack, ND-Not Detected, NS- Not Significant, *Significant at 5% level

3.4. Saponin content of the ready-to-eat coconut based snack

Table.4. describes the saponin content of the ready-to-eat coconut based snack. Saponins find extensive application in hormone therapy and also used in pharmaceutical preparations. Such applications are principally due to its foaming ability with the production of frothy effect. Saponins are described glycosides of triterpenes and sterols and are used as emulsifying agents and an expectorant (24).

It was observed that there was a drastic reduction of saponins when the samples were subjected to hot air oven drying, since the heat stability of saponins is highly dependent on process parameters namely time, temperature and pH. The range of % gain of saponins in impregnated samples subjected to freeze drying was 41% to 58.14% and that of samples dehydrated using hot air oven drying was 34.7% to 50%. However, there existed a significant difference at $p \leq 0.05$ among the T_1 and T_2 samples. Guclu-Ustundag et al., (25) reported that saponin gets destructed when subjected to heat treatments beyond 100^{o}C-140^{o}C and above, but they remain stable below the higher temperatures. Hence thermal stability of saponins was assessed based on conditions such as temperature, pH and time.

Table.4. Saponin (mg) content of the ready-to-eat coconut based snack

Samples	Osmotic medium	T_1	% gain	T_2	% gain	p-value
Control	ND	0.21±0.04	-	0.34±0.05	-	-
A	1.9	0.66±0.01	34.7	0.78±0.007	41.00	0.000*
B	0.79	0.39±0.007	49.36	0.42±0.05	53.16	0.000*
C	0.86	0.43±0.003	50.00	0.50±0.001	58.14	0.000*
D	0.81	0.37±0.002	45.67	0.46±0.002	56.79	0.001*

All values are means of triplicate determinations± standard deviation (SD), T_1- Hot Air Oven Drying, T_2- Freeze Drying, Sample A-*Mentha piperita*, Sample B-*Zingiber officinale*, Sample C-*Daucus carota* and Sample D-*Beta vulgaris* filtrate impregnated coconut based snack, ND-Not Detected, *Significant at 5% level

3.5. Total flavonoid content of the ready-to-eat coconut based snack

Total flavonoid content of the ready-to-eat coconut based snack is discussed in Table.5. Flavonoids are imperative for their ability to perform as natural antioxidants in foods. Dietary intake of the flavonoids, quercetin and its glycosides range from 23 to 500 mg per day (26). Consumption of flavonoids in milligram basis is recommended in addition with other antioxidants vitamin E and carotenoids. Due to its excellent antioxidant properties, flavonoids are being supplemented through balanced diets to protect body from harmful oxidative stresses.

The flavonoid and quercetin content of all the impregnated samples subjected to freeze drying showed an increment when compared with hot air oven dried samples which was statistically significant at $p \leq 0.05$. Among the freeze dried samples, the highest flavonoid content was observed in sample C impregnated with *Daucus carota* 59.56 ($p \leq 0.05$), followed by T_2A-31.21, T_2D-23.16 and T_2B-21.89. The flavonoid gets destructed at temperature 30^{o}C to 100^{o}C. Hence the impregnated samples dehydrated using hot air oven drying showed reduction ($p \leq 0.05$) in the flavonoid contents when compared to freeze dried samples. But in the present study the hot air oven dried samples were subjected to 45-50^{o}C which could have slightly preserved the flavonoid contents. The finding of the study was reliant to the result of Zhou et al., (27) who reported that flavonoid and total phenolic contents were found significantly higher in freeze dried food samples than conventional-heat dried samples.

Table.5. Total flavonoid (mg GAE) content of the ready-to-eat coconut based snack

Samples	Osmotic medium	T_1	% gain	T_2	% gain	p-value
Control	ND	0.83±0.1	-	1.11±0.45	-	0.036*
A	42.3	19.23±1.2	45.46	31.21±2.3	73.78	0.000*
B	39.8	15.67±2.1	39.38	21.89±3.4	55.00	0.005*
C	83.5	34.6±0.09	41.43	59.56±0.09	71.33	0.000*
D	32.56	12.06±0.04	37.00	23.16±0.1	71.13	0.000*

All values are means of triplicate determinations± standard deviation (SD), T_1- Hot Air Oven Drying, T_2- Freeze Drying, Sample A-*Mentha piperita*, Sample B-*Zingiber officinale*, Sample C-*Daucus carota* and Sample D-*Beta vulgaris* filtrate impregnated coconut based snack, ND-Not Detected, *Significant at 5% level

3.6. Quercetin content of the ready-to-eat coconut based snack

Table.6. explains the quercetin content of the ready-to-eat coconut based snack. The quercetin content of all the hot-air oven dried samples depicted a slight decrement in values when compared with T_2 samples and showed a significant difference at $p \leq 0.05$. The greatest quercetin content was observed in impregnated samples subjected to freeze drying and the descending order of presence in the samples has been represented as sample A-3.98, sample B-3.87, sample C-1.421 and sample D-1.3. Generally the quercetin content gets destroyed at 30 to 100^{o}C could be reason for the reduction in quercetin content in the impregnated samples subjected to hot-air oven drying when compared with freeze dried samples. In the present study, the temperature i.e. used 45-50ºC might have preserved the quercetin content from maximal destruction.

This finding was made in agreement with the results of Zainol et al., (28) who reported that the percent degradation of flavonoids like quercetin was 73.5%, 87.6%, 97%, naringin was 43.4%, 74.3%, 76.7%, rutin was 31.4%, 63.3%, 76.8%, and catechin was 34.9%, 65.2%, 78.1% which were obtained by the three drying methods namely freeze drying (–20°C for 24 hours), vacuum oven (45°C for 5 hours) and air oven drying (45°C for 48 hours) respectively in *C.asiatica* leaf. However freeze dried samples found to contain greatest flavonoid content with minimal destruction. Since the flavonoids and phenolics might be destroyed by oxidative reactions when exposed in the atmosphere for prolonged time, however the temperature was much lesser.

Table.6. Quercetin (mg) content of the ready-to-eat coconut based snack

Samples	Osmotic medium	T_1	% gain	T_2	% gain	p-value
Control	ND	ND	-	ND	-	-
A	7.4	3.11±0.005	42.02	3.98±0.013	53.78	0.182^{NS}
B	6.8	2.89±0.003	42.5	3.87±0.082	56.9	0.04*
C	2.4	1.30±0.001	54.16	1.421±0.004	59.2	0.01*
D	2.2	0.67±0.018	30.45	1.3±0.002	59.1	0.07^{NS}

All values are means of triplicate determinations± standard deviation (SD), T_1- Hot Air Oven Drying, T_2- Freeze Drying, Sample A-*Mentha piperita*, Sample B-*Zingiber officinale*, Sample C-*Daucus carota* and Sample D-*Beta vulgaris* filtrate impregnated coconut based snack, ND-Not Detected,NS- Not Significant,*Significant at 5% level

3.7. Total phenol content of the ready-to-eat coconut based snack

The Total phenol content of the ready-to-eat coconut based snack is interpreted and discussed in Table.7. The degradation of total phenols (mg) is observed at temperature beyond 50-60°C of heat treatments in foods. Hence the total phenol content in the impregnated samples subjected to hot air oven drying was slightly depleted. Among the hot air oven dried samples maximum total phenol content was observed in sample T_1A- 28.45 and among freeze dried samples (T_2A- 43) had the highest total phenol content. There existed a significant difference at $p \leq 0.05$.

The slight depletion of total phenols in the present study was in par with the outcome of Abascal et al., (19) who studied that oven-drying at higher temperatures contributed substantial losses of polyphenols, tannins and antioxidant capacity. Freeze-dried marion berries, strawberries and corn constantly had a greater amount of phenolic content when compared with air-dried samples. Raksakantong et al., (29) reported that white cabbage when dried under hot air revealed a decrement in phenolic content more than 60%. However in the present study, drying of samples by hot air reduced considerable amounts of phenolic compounds which are essential for nominal health benefits.

Table.7. Total phenol (mg GAE) content of the ready-to-eat coconut based snack

Samples	Osmotic medium	T_1	% gain	T_2	% gain	p-value
Control	ND	8.782±0.017	-	12.09±0.008	-	0.000*
A	57.84	28.45±0.03	49.18	43±0.1	74.34	0.000*
B	21.3	12.33±0.01	57.88	15.91±0.07	74.7	0.000*
C	54.3	27.17±0.03	50.03	39.97±0.1	73.61	0.000*
D	13.5	6.535±0.31	48.41	9.7±0.110	71.85	0.000*

All values are means of triplicate determinations± standard deviation (SD), T_1- Hot Air Oven Drying, T_2- Freeze Drying, Sample A-*Mentha piperita*, Sample B-*Zingiber officinale*, Sample C-*Daucus carota* and Sample D-*Beta vulgaris* filtrate impregnated coconut based snack, ND-Not Detected, *Significant at 5% level

In the present research, the freeze dried samples found to possess slightly higher total phenols was consistent with the outcome of Hung and Duy (30) who investigated that freeze-drying preserves the phenols, which are responsible for the antioxidant properties from maximum destruction when compared to conventional heat-drying method in vegetable extracts. He reported that prolonged drying resulted in oxidation of phenolic compound by enzyme phenol oxidases in yacon chips and exhibited a lowest antioxidant activity at 40-60°C. Sang et al., (31) reported that thermal drying resulted in losses of polyphenols when compared with fresh counterparts ascribed to enzymatic degradation and degradation of phytonutrients.

3.8. β-carotene content of the ready-to-eat coconut based snack

Table.8. clarify the β-carotene content of the ready-to-eat coconut based snack. The carotenoids and beta carotenes in foods gets depleted when exposed to oxygen, and temperature beyond 57ºC with approximately 54 % of loss. The beta carotene levels were higher ($p \leq 0.05$) in all freeze dried samples than hot air dried samples. The maximum beta carotene content was seen in T_2 C-1287.8 and T_2A-1286.6 subjected to freeze drying because of its abundant nature of betacarotene present in the plant produce.

Table.8. β-carotene (µg) content of the ready-to-eat coconut based snack

Samples	Osmotic medium	T_1	% gain	T_2	% gain	p-value
Control	ND	ND	-	ND	-	-
Sample A	1886.7	941.2±0.02	49.88	1286.6±0.26	68.19	0.000*
Sample B	38.3	23.21±0.01	60.60	28.46±0.04	74.30	0.000*
Sample C	1854.2	1237±01.0	66.71	1287.8±0.01	69.45	0.000*
Sample D	4.02	2.011±0.03	50.02	2.9±0.09	72.13	0.000*

All values are means of triplicate determinations± standard deviation (SD), T_1- Hot Air Oven Drying, T_2- Freeze Drying, Sample A-*Mentha piperita*, Sample B-*Zingiber officinale*, Sample C-*Daucus carota* and Sample D-*Beta vulgaris* filtrate impregnated coconut based snack, ND-Not Detected, *Significant at 5% level

Joshi and Mehta (32) reported that drying resulted in reduced beta carotene content in mint, curry, gogu and amaranth ranged 24 to 40% in sun dried leaves and 6 to 25% in oven dried leaves. It is reported that degradation of carotenoids occur in sea buckthorn leaves at temperatures from 50°C to 100°C with mild to drastic reductions through heat treatments. It is observed that heat treatments have an undesirable effect on the total carotenoid content of plant foods.

3.9. Antioxidant activity (FRAP) (µg FeSO4 equivalents) of the ready-to-eat coconut based snack

Table.9. illustrates the total antioxidant activity of the ready-to-eat coconut based snack. Irrespective of the osmotic medium infused, the samples subjected to freeze drying found to possess increased total antioxidant activity which could be attributed due to the effect of osmotic dehydration, the diffusion mechanism and the preservation nature of freeze drying methods. Nevertheless, the higher total antioxidant activity was observed in sample A (T_1A- 9000 µg and T_2A- 9300 µg), followed by sample C (T_1C- 8900 µg and T_2C- 8683 µg) sample D (T_1D- 7432 µg and T_2D-7943 µg) and finally sample B (T_1B-7400 µg and T_2B-7888 µg). The declining trend shows the abundant nature of phytonutrients (carotenoids and vitamin C, vitamin E, vitamin A, flavonoids and phenols) present in the plant produce.

The antioxidant activity of the snack was dependent principally on the phenolic derivatives. Rice-Evans et al., (33) who reported that phenolic compounds contains more antioxidant power than carotenoids and vitamin C. Shyamala and Jamuna (18) reported that carrots and beet roots consists of powerful antioxidants like phenolic compounds, flavonoids, carotenoids and vitamins which are used to produce various ready to eat foods. McKay and Blumberg (7) reported that mentha species generally contain flavonoids, phenolic acids which exhibits antioxidant activity owing to their redox characteristics and free radical scavenging effects. The pungent principle 6-gingered in ginger found to possess greatest antioxidant activity (8).

Table.9. Antioxidant activity (µg FeSO4 equivalents) of the ready-to-eat coconut based snack

Filtrate of functional ingredients	T_1		T_2		p-value
	Control	Samples	Control	Samples	
A	6051 ± 0.04^{a1}	9000 ± 0.400^{b1}	6244 ± 0.08^{a1}	9300 ± 0.500^{d1}	0.003*
B		7400 ± 0.320^{b2}		7888 ± 0.150^{d2}	0.002*
C		8900 ± 0.380^{b1}		8683 ± 0.320^{d1}	0.001*
D		7432 ± 0.090^{b2}		7943 ± 0.09^{d2}	0.003*
p-value (Control vs Sample)	0.001*		0.002*		

All values are means of triplicate determinations± standard deviation (SD), T_1- Hot Air Oven Drying, T_2- Freeze Drying, Sample A-*Mentha piperita*, Sample B-*Zingiber officinale*, Sample C-*Daucus carota* and Sample D-*Beta vulgaris* filtrate impregnated coconut based snack, Rows followed by different alphabets and columns followed by different numerals are *Significantly different ($p\leq0.05$), NS- Not Significant by LSD.

In the present study, the slight decrement in phenolic content and other vitamins in T_1 samples contributed slightly diminished antioxidant activity than T_2 samples. Raksakantong et al., (29) reported that decrement of total phenol content estimated about 60% due to exposure of hot air drying. The major disadvantages of prolonged hot air drying time resulted in oxidation of pigments, deleterious effect on vitamins etc., The low temperature at long drying times promote a decline in antioxidant capacity (FRAP). The loss that occurred due to heat treatment of the samples results in degradation of phenolic constituents or bioactive components. Hence various drying methods have varying influence on FRAP value.

IV. Conclusion

Fruits, nuts and green leafy vegetables rich in phytochemicals are an imperative module of healthy diet. They are the substances found as a natural bio active component of foods that have been determined to be beneficial to the human body. The present research focused on studying the effect of drying methods and impregnation of filtrate of functional ingredients namely *Mentha piperita*, *Zingiber officinalis*, *Daucus carota*, *Beta vulgaris* on the quality characteristics of ready to eat coconut based snack food. The ready to eat coconut based snack food utilizing the filtrate of functional ingredients adopting the freeze drying and hot air oven drying methods revealed favourable results in functional characteristics than control. However the ready to eat coconut based snack food developed using hot air oven drying revealed to be the best with high acceptability sensory scores. Hence, the developed ready to eat coconut based snack could serve as a healthy food for all the age groups which complements the food security of the nation.

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