GIDA (2012) 37 (6): 317-324 *Research* / Araştırma

DEVELOPMENT OF *Cocos nucifera* CHIPS IMPREGNATING *Beta vulgaris* EXTRACT AS AN OSMOTIC MEDIUM

Meenakshisundaram Sivasakthi*, Narayanasamy Sangeetha

Department of Food Science and Technology, Pondicherry University, Puducherry, India.

Received / Geliş tarihi: 15.07.2012
Received in revised form / Düzeltilerek Geliş tarihi: 22.08.2012
Accepted / Kabul tarihi: 24.10.2012

Abstract

The effect of sucrose and beet root (*Beta vulgaris*) extract infusion on osmotic pretreatments assisted with dehydration methods (hot air drying) on proximate, physical, physico-chemical, sensory, color and textural properties of coconut chips were analyzed. Coconut slices of thickness 0.5 and 0.8±0.1 mm were osmotically pretreated in sucrose solutions of different concentrations (100%, 90%, 80%) with or without the infusion of beet root extract (5%, 10% and 15%) for about 30 and 60 minutes respectively due to its varying thickness. After the osmotic process, the slices were further dehydrated in hot air oven at temperature 50-60 °C for 7 to 8 hours. Osmotic medium without the infusion of beet root extract serves as the control. The selected chips of (0.5 and 0.8 ± 0.1 mm) made with the composition of 100 % sucrose solution containing 15% of beet root extract infusion when compared with control revealed favourable significant difference in proximate principles like carbohydrate, total sugars, ash, energy and physical parameters like weight reduction, solid gain, water loss, color, texture, rehydration properties and pH (physico-chemical property) with greater sensory scores of 8.1 at 5% level ($p \leq 0.05$) than control chips.

Keywords: Osmotic dehydration, *Beta vulgaris*, mass transfer, sensory evaluation, coconut

OZMOTİK ORTAM OLARAK *Beta vulgaris* ÖZÜTÜ İLE *Cocos nucifera* CİPSİ ELDE EDİLMESİNİN ARAŞTIRILMASI

Özet

Sakkaroz ve şeker pancarı ekstraktı infüzyonunun, hindistancevizi cipsinin fiziksel, fizikokimyasal, duyusal, renk ve tekstür özellikleri üzerine dehidrasyon yöntemleri (sıcak hava kurutma) destekli ozmotik önişlemlerin etkisi incelendi. Kalınlığı 0.5 ve 0.8±0.1 mm olan hindistancevizi dilimlerine, farklı konsantrasyonlarda (%100, %90 ve %80) şeker pancarı ekstraktı infüzyonu varlığında (% 5, %10 ve % 15) ve bu infüzyon olmadan kalınlığa bağlı olarak 30-60 dakika ozmotik önişlem uygulanmıştır. Ozmotik işlemden sonra, dilimler etüvde 50-60 °C'da 7-8 saat süre ile ilave kurutma işlemi uygulanmıştır. Şeker pancarı ekstresi infüzyonu olmayan ozmotik ortam, kontrol olarak kullanılmıştır. Kontrol ile karşılaştırıldığında, %15 şeker pancarı ekstresi infüzyonu eklenmiş % 100 sakkaroz çözeltisi ile hazırlanmış cipslerin karbohidrat, toplam şeker, kül, enerji içeriği ile ağırlık kaybı, katı madde kazanımı, nem kaybı, renk, tekstür, kuruma özellikleri ve pH açısından önemli derecede ($P \leq 0.05$) üstün olduğu görülmüştür.

Anahtar kelimeler: Ozmotik dehidrasyon, *Beta vulgaris*, kütle transferi, duyusal değerlendirme, hindistancevizi

[1]*Corresponding author* / Yazışmalardan sorumlu yazar ;
lillybol99@gmail.com , (+91) 9488260590 , (+91) 413 2655033/734

INTRODUCTION

Coconut (*Cocos nucifera*) is the king of vegetables with its sap, fruits, leaves, stem, root and all parts to feed, appease shelter, cure and carry mankind. The coconut plays major role in daily foods, traditional identity and acts as a functional food, also possess biologically active components thought to enhance health and wellbeing. (1).

Coconut is composed of fatty acids especially the medium chain saturated fatty acids, which allows them to be directly absorbed from the intestine and sent straight to the liver to be metabolized for energy production (2). In the emerging modern scenario, the convenience coconut products have been manufactured in the countries which are being consumed among public (3). Fruits, roots, nuts and vegetables rich in nutraceuticals are an important component of healthy diet. The beetroot an excellent nutraceutical food used for the treatment of various ailments. (4).

Osmotic dehydration is a process that entails the partial removal of water of food items such as vegetables and fruits. Osmotic dehydration enables fruits and vegetables to be stored for a longer period of time. The components rich in antioxidants-carotenoids, minerals, microorganisms or vitamins found in plant materials which are infused as an osmotic medium in the process of osmotic dehydration, used to improve the nutritional, sensorial, and functional properties of food without changing its integrity (5, 6).With this as a background, the present study was focused on osmotic dehydration of coconut slices by infusion of beet root extract as an osmotic medium.

MATERIALS AND METHODS

Sample preparation

Fresh and matured good quality coconuts were purchased from Pazhamudir Nilayam, Puducherry prior to each set of experiments for osmotic dehydration. The coconuts were pre-processed which involves selection of matured coconut, removal of husk, breaking into 2 halves, separation of endosperm from shell and removal of testa with the help of a knife and at last slicing was done. Fresh beet roots of deep red color also obtained from the same place and its juice was extracted to infuse with osmotic medium for various experimental treatments.

Standardization of process parameters involved in formulation of enriched coconut chips

As the thickness of the slice increases, the osmotic dehydration phenomenon will decrease, due to more thickness of the slice, it is more difficult for the solute from the solution to penetrate inside the fruit slices (7). Osmotic dehydration was done for the three thickness of slices (0.5, 0.8 and 1 mm) at constant 40% of sugar solution followed by hot-air drying process. Based on the appearance, crispiness and sweetness and other sensory trials, the thickness of the slices 0.5 and 0.8±0.1 mm were selected.

The weight of slices and brix values of osmotic medium of first half an hour and one hour for the 0.5 mm±0.1 mm and 0.8 mm±0.1 mm slices were taken for the respective slices using 40% of sugar solution. Further OD for the respective slices were done using 50%, 60%, 70%, 80%, 90% and 100% of sucrose solutions for half an hour and one hour. The coconut chips of both the slices made with higher concentrations 80%, 90% and 100% were selected which gave acceptable texture, firmness, crispiness and sweetness. The extract obtained from fresh beet root of 5%, 10% and 15% was added to the standardized sucrose concentration and mass transfer parameters were observed during the process of osmotic dehydration. Osmotic medium without the infusion of mint extract serves as the control.

The slices after osmotic dehydration was dried at 50-60°C to get dried chips for a period of 7 to 8 hours based on the earliest studies where most of the fruits and vegetables are dried at 50-60 °C (8). Twelve treatments have been undertaken during standardization process using 0.5, 0.8 ±0.1 mm slices with duration of 30 and 60 minutes and out of these 12 treatments, the best treatments in which the coconut chips made with 100% of sucrose solution (control) and 100% of sucrose solution with the infusion of 15% of beet root (*Beta vulgaris*) extract as an osmotic medium have been selected based on the appearance and desirable characteristics of sweet chips like crispiness, sweetness, odor and color changes.

Quality analysis of the coconut chips

The methods adopted in the quality evaluation of coconut chips (0.5±0.1 mm and 0.8±0.1 mm) have been detailed. The physical parameters Weight Reduction (%WR), Solid Gain (%SG) and Water Loss (%WR) were analysed using the procedures suggested by Mavroudis et al.(9), Ozenet al. (10), Rehydration characteristics - Rethinam and Bosco (11), pH -AOAC (12), Acidity-Grigelmo-Miguel and Martin-Belloso (13,14),Carbohydrates -AOAC (15,29), Protein, Calcium Phosphorus, Iron, Saponification value, Vitamin C and E –Raghuramalu et al. (16), Fat, Moisture, Ash,Dietary fibre -AOAC Method (17), Potassium Selenium, Chromium - Lawrence Evans Pharmacopeial Forum (18), Free fatty acids, Peroxide value- Akubugwoet al. (19). The best selected treatments were done in triplicate as a confirmatory test and these treatments were analyzed for physical, chemical and sensorial traits.

Statistical analysis

The statistical analysis of the results of the sensory, physical and chemical analysis was done in triplicate by taking the mean of the selected samples for all the treatments. Statistical tool independent sample t test, 18 version of the SPSS Software was applied to compare the means to determine the most acceptable treatment ($p \leq 0.05$).

RESULTS AND DISCUSSION

Based on the sensory and organoleptic properties as documented by Meilgaard et al. (20), the chips made with 100% sucrose solution with or without the infusion of beetroot extract have been selected possessing more acceptable score on color, flavor, crispiness (texture), taste and overall acceptance. The best selected chips were analyzed for quality traits such as follows:

Weight reduction (%) of the coconut chips

The weight reduction (%) of the chips is discussed in Table 1. It was depicted that gradual reduction in weight was shown from every 5 min to 30 min. The most significant changes in weight reduction was seen between the control and enriched coconut chips during the first 10 min 13.59 and 13.98 followed by 20 min 27.1, 27.96 and 30 min 40.7 and 41.95 respectively. On comparison, the weight reduction was found slightly increased in enriched coconut chips. This is due to the uptake of more sugars from the beetroot infusion.

In case of 0.8±0.1 mm sliced chips, very least significant difference was found when control values (1.42 to 7.12) at first 10 min of OD compared with ECC (1.44 to 6.81) at the same time. Whereas the weight reduction was minimum in control (42.70) than ECC of (43.27) with respect to initial values. Irrespective of the thickness 0.5±0.1 mm and 0.8±0.1 mm sliced coconut chips, the weight reduction was maximum in beet infused chips of 60 min duration than control with significant difference. This result was match with Torreggiani et al. (7), the weight reduction increases with increase in time due to more solute absorption.

Table 1. Weight Reduction (WR%) of the coconut chips

Time of OD	Coconut chips (0.5 ±0.1mm)		*p* value	Time of OD	Coconut chips (0.8 ±0.1mm)		*p* value
	Control	ECC			Control	ECC	
0 min	1.35±0.001	1.39±0.0002	0.000*	0 min	1.42±0.002	1.44±0.0002	0.000*
5 min	6.79±0.101	6.99±0.002	0.29^{NS}	10 min	7.12±0.001	6.81±0.0002	0.000*
10 min	13.59±0.002	13.98±0.0002	0.000*	20 min	14.23±0.003	14.42±0.0002	0.000*
15 min	20.3±0.100	20.9±0.002	0.001*	30 min	21.35±0.050	21.63±0.0002	0.001*
20 min	27.1±0.002	27.96±0.0001	0.000*	40 min	28.46±0.001	27.82±0.0002	0.000*
25 min	33.98±0.035	34.9±0.0002	0.000*	50 min	35.58±0.005	36.05±0.0002	0.000*
30 min	40.7±0.003	41.95±0.02	0.000*	60 min	42.70±0.091	43.27±0.020	0.339^{NS}

*Significant difference at 5% level, NS-Not Significant, ECC-Enriched Chips

The Solid gain (%) of the chips is discussed in Table 2. With regard to solid gain among the two thicknesses (0.5±0.1 mm and 0.8±0.1 mm) sliced coconut chips, significant difference was found at 5% level. In case of 0.5 mm sliced chips the maximum significant difference was observed from every 5 min to 30 min (0.01 to 0.46). Whereas the significant difference was found maximum in 0.5±0.1 mm sliced enriched coconut chips than control (0.32 to 0.96) at 0 min to 30 min of the osmotic process.

Water loss (%) of the coconut chips

The water loss (%) of the chips is discussed in Table 3. Regarding water loss of coconut chips of both the thickness, significant difference was observed at 5% level. In case of 0.5 mm sliced enriched chips, the greater significant difference was observed from every 5 min to 30 min (1.43 to 42.91) which was greater than control chips at osmotic duration of 0 to 30 min.

Table 2. Solid Gain (SG%) of the coconut chips

Time of OD	Coconut chips (0.5 ±0.1mm)		*p* value	Time of OD	Coconut chips (0.8 ±0.1mm)		*p* value
	Control	ECC			Control	ECC	
0 min	0.01±0.001	0.32±0.0002	0.000*	0 min	0.04±0.0005	0.06±0.0002	0.000*
5 min	0.08±0.001	0.16±0.0002	0.000*	10 min	0.22±0.001	0.31±0.0002	0.000*
10 min	0.15±0.001	0.32±0.0002	0.000*	20 min	0.45±0.001	0.62±0.002	0.000*
15 min	0.23±0.002	0.48±0.0004	0.000*	30 min	0.67±0.005	0.93±0.0002	0.000*
20 min	0.31±0.001	0.64±0.0002	0.000*	40 min	0.90±0.0005	1.24±0.0002	0.000*
25 min	0.38±0.20	0.80±0.002	0.000*	50 min	1.13±0.001	1.55±0.0002	0.000*
30 min	0.46±0.002	0.97±0.002	0.000*	60 min	1.35±0.001	1.86±0.0002	0.000*

*Significant difference at 5% level, NS-Not Significant, ECC-Enriched Chips

On analyzing the coconut chips of thickness 0.8 mm slices, the maximum solid gain was found from every 10 min up to 60 min (0.04 to 1.35), in which the significant difference was found less than enriched coconut chips, whereas the solid gain increased from 0.06 to 1.86 at the end of 60 min. On comparing the two thicknesses of coconut chips, 0.8±0.1 mm showed maximum increase in solid gain than 0.5±0.1 mm chips, this could be attributed to more uptake of solute during osmotic dehydration process. Time has significant effect on solid gain (sugar uptake) and moisture loss (21).

On analyzing the coconut chips of thickness 0.8±0.1 mm sliced, the maximum water loss was found from every 10 min to 60 min (1.46 to 44.05), in which the significant difference was found less than enriched chips, whereas the water loss increased from (1.50 to 45.12) at the end of the 60 min. Water loss increases as the solute concentration increases. This result was match with Rastogi and Raghavarao (21), the weight reduction increases with increase in time due to more solute absorption.

Table 3. Water loss (WL%) of the coconut chips

Time of OD	Coconut chips (0.5 ±0.1mm)		*p* value	Time of OD	Coconut chips (0.8 ±0.1mm)		*p* value
	Control	ECC			Control	ECC	
0 min	1.37±0.0005	1.43±0.0002	0.000*	0 min	1.46±0.001	1.50±0.0002	0.000*
5 min	6.87±0.001	7.15±0.0002	0.000*	10 min	7.34±0.000	7.12±0.0002	0.000*
10 min	13.75±0.01	14.30±0.0002	0.000*	20 min	14.68±0.015	15.04±0.0002	0.000*
15 min	20.62±0.02	21.45±0.0002	0.000*	30 min	22.02±0.016	22.56±0.0002	0.000*
20 min	27.50±0.002	28.61±0.0002	0.000*	40 min	29.36±0.01	29.08±0.0002	0.000*
25 min	34.38±0.007	35.76±0.002	0.000*	50 min	36.71±0.005	37.60±0.002	0.000*
30 min	41.26±0.005	42.91±0.002	0.000*	60 min	44.05±0.34	45.12±0.001	0.006*

*Significant difference at 5% level, NS-Not Significant, ECC-Enriched Chips

Rehydration ratio of the coconut chips

Rehydration ratio of the chips is discussed in Table 4. It was depicted that gradual increase in rehydration ratio shown from 5 min to 25 min, the most significant changes in rehydration ratio was seen between the control and enriched coconut chips. Whereas the significant difference was found maximum in 0.5±0.1 mm sliced control chips when compared to the enriched coconut chips.

The texture of the chips which was analyzed by the texture analyzer revealed less force 3.3 (N) was required to break the chips of 0.5±0.1 mm thickness; whereas the higher force 5.5 (N) was used to break the chips of 0.8±0.1 mm due to the varying thickness. The increase in time and solute concentration decreases the texture of the osmotic dehydrated chips (24). Textural characteristics depend on the biophysical characteristics of the products.

Table 4. Rehydration ratio of the coconut chips

Time of OD	Coconut chips (0.5 ±0.1mm)		*p* value	Time of OD	Coconut chips (0.8 ±0.1mm)		*p* value
	Control	ECC			Control	ECC	
5 min	1.25±0.05	1.19±0.0002	0.000*	5 min	1.11±0.004	1.12±0.0002	0.022*
10 min	1.39±0.001	1.40±0.0002	0.001*	10 min	1.21±0.001	1.50±0.0002	0.000*
15 min	1.46±0.0002	1.62±0.0002	0.000*	15 min	1.23±0.0002	1.55±0.0002	0.000*
20 min	1.93±0.015	1.87±0.002	0.003*	20 min	1.43±0.0002	1.71±0.0002	0.000*
25 min	1.93±0.0125	1.87±0.0002	0.002*	25 min	1.92±0.0002	1.89±0.0002	0.000*
30 min	1.93±0.0125	1.87±0.0002	0.002*	30 min	1.92±0.0002	1.89±0.0002	0.000*

*Significant at 5% level NS-Not SignificantECC-Enriched Chips

On examining the coconut chips of thickness 0.8±0.1 mm, the maximum rehydration was found from every 10 min up to 60 min (1.11 to 1.91) in control chips which was higher than enriched chips rehydration ratio was (1.12 to 1.89). Rehydration is a complex process aimed at the restoration of raw material properties when dried material is contacted with water (22).

Color and texture analysis of the coconut chips

The results of the color and texture analysis of the chips are given in Table 5. On analyzing the color values of 0.5±0.1 mm sliced chips, hue value was less (-1.3) in control when compared to ECC (0.8), whereas the chromo values also shown less (1.9) when compared to ECC (7.9).In case of 0.8±0.1 mm chips, the hue value was minimum (-1.4) when compared with ECC (0.8). Similarly the chromo values also found less (2.4)when compared with ECC (6.9) .The ECC of thickness 0.5±0.1 mm had highest ΔE value (9.5) when compared with 0.8±0.1 mm ECC (4.0) due to varying thickness and absorption mechanism. The colour of the chips changes during dehydration not only due to evaporation of water, migration of pigments but also due to browning, enzymatic browning and caramelisation (23).

Table 5. Color and texture analysis of the coconut chips

Coconut chips	Hue value	Chroma value	ΔE	Texture (N)
0.5 mm control chips	-1.3	1.9	-	3.3±0.0
0.5 mm Enriched Chips	0.8	7.9	9.5	3.4±0.0
0.8 mm controlchips	-1.4	2.4	-	5.5±0.0
0.8 mm Enriched Chips	0.8	6.9	4.0	5.6±0.0

pH property of the osmotic solution

Regarding the pH of osmotic solution, there was a gradual decrease in pH from every 5 min to 30 min in 0.5±0.1 mm sliced coconut control chips (6.95 to 6.79). In 0.5±0.1 mm enriched coconut chips there was gradual decrease in pH from every 5 min to 30 min (6.95 to 6.79).In case of 0.8±0.1 mm sliced control coconut chips there was gradual decrease in pH from 6.95 to 6.77. Whereas in case of 0.8±0.1 mm sliced enriched coconut chips there was gradual decrease in pH from every 10 min to 60 min (6.15 to 5.43).The significant changes arise in pH due to the infusion of organic acids from the sample and beet root extract into the solution. These results match with Hussain et al. (24).

Nutrient composition of the coconut chips

The nutrient composition of the coconut chips is displayed in Table 6. In case of carbohydrates, irrespective of the thickness the Carbohydrate content of the control and enriched coconut chips did not vary much which was statistically found significant. The carbohydrate content of the control chips was less when compared to the enriched coconut chips (27.8) in 0.5±0.1 mm sliced coconut chips.

In case of 0.8±0.1 mm sliced coconut chips Carbohydrate content was more in enriched chips (28.1) when compared with control chips. The increase is due to the diffusion of sucrose from osmotic solution to the food matrix by Bchir et.al. (5).The total sugar content of the enriched chips was found maximum (28.3) with significant difference on comparison made with control chips 0.5±0.1 mm sliced chips, whereas the same trend was observed in 0.8±0.1 sliced chips with greater total sugar content.

Regarding the protein content, lesser values in enriched chips (0.97) was found with respect to the control chips due to degradation of protein during drying process in association with osmotic pretreatment. In 0.8±0.1 mm sliced coconut chips, the protein content was less in enriched chips (1.00) than the control (1.09). As far as the protein content of the chips (0.5 and 0.8±0.1 mm) concerned, there was not much difference in their levels of the control and enriched coconut chips. The biological value of dried proteins varies with the drying procedure. In the present study, drying at temperature 50-60 °C might have affected the protein content. However protein, mineral and organic acid diffusion by osmosis contributed to a better flavor of the osmotic solutions (5).

Prolonged exposure of high temperature can affect the functional properties. Low temperature treatment of protein may in some cases increases the digestibility of the proteins over the native material. Solute diffusion flow from fruit to osmotic solution has an important effect on sensorial and nutritional value of the product (25).In case of fat, 0.5±0.1 mm control chips had higher value (37.14) when compared to the enriched coconut chips (37.12). In case of 0.8±0.1 mm sliced coconut chips, the fat content of control chips (37.9) was not shown any significant difference when compared to the enriched coconut chips. Irrespective of the thickness, the fat content of control and enriched chips did not vary much, hence nutrient retention was observed prior to osmotic dehydration (26).

On analyzing 0.5±0.1 mm sliced chips, moisture content of the control chips was higher (3.08) when compared to the enriched chips (0.84). In case 0.8±0.1 mm sliced coconut chips moisture content was less (0.73) when compare to the control. Regardless of the thickness, the moisture content of control and enriched coconut chips did not vary much. Which was statistically forms the non-significant more or less comparable with the control. The first goal of drying process research in the food industry is to achieve a precise control of the product moisture content at the end of the drying process (22).

In case of 0.5±0.1 mm sliced chips, ash content of the control chips and the enriched chips was not vary much with no significant difference. In

Table 6.Nutrient composition of the coconut chips

Nutrients	Coconut chips (0.5 ±0.1mm)		*p* value	Coconut chips (0.8 ±0.1mm)		*p* value
	Control	ECC		Control	ECC	
Carbohydrate (g)	26.58±0.540	27.80±0.200	0.022*	27.37±0.38	28.1±0.39	0.045*
Total sugars (g)	25.87±1.10	28.30±0.200	0.020*	22.33±0.32	27.35±0.38	0.025*
Protein (g)	1.04±0.004	0.97±0.0002	0.004*	1.09±0.01	1.00±0.002	0.000*
Fat (g)	37.14±0.47	37.12±0.00	0.33^{NS}	37.97±0.01	37.91±0.06	0.951^{NS}
Moisture (g)	3.08±0.005	0.84±0.0002	0.000*	3.44±0.020	0.73±0.002	0.000*
Ash (g)	1.72±0.027	1.78±0.002	0.047*	2.40±0.200	2.72±0.020	0.05*
Dietary fiber (g)	3.86±0.005	3.88±0.002	0.33^{NS}	3.86±0.000	3.98±0.010	0.025*
Energy (Kcal)	444 ±14.78	450±0.01	0.023*	455±0.400	457±0.00	0.000*

*Significant at 5% level NS-Not Significant ECC-Enriched Chips

0.8±0.1 mm sliced chips, ash content of the enriched coconut chips (2.72) was slightly more than that of control (2.4) which was significant at 5% level. The fiber content of the 0.5, 0.8±0.1 mm sliced coconut chips of the control was less (3.86 and 3.88) when compared to enriched chips (3.88 and 3.98). In 0.5±0.1 mm sliced coconut chips, less calorific value was found in control (444) than that of the enriched chips (450). In case of 0.8±0.1 mm sliced chips, high calorific value was found in ECC (457) when compared to control. Incorporation of physiologically active compounds into food tissue without destroying the initial food matrix have already been endeavored by many researchers, which affects the nutritional and sensory characteristics of the foods (27-28).

Sensory analysis of the coconut chips

The results of the sensory analysis of chips is given in Figure 1. Sensory scores of the chips obtained by organoleptic evaluation in case of 0.5±0.1 mm sliced chips, enriched coconut chips has got a highest score (8.1) when compared to the control chips. Regarding the colour and appearance attributes, enriched coconut chips scored higher 7.8 when compared to the control chips. Regarding crispiness, enriched coconut chips had greater score of 8.0 when compared with control chips. The 0.5±0.1 mm enriched coconut chips had good taste with a high score of 8.1 when compared to control. Albagnac et al. (25) showed that the solute diffusion flow from fruit to osmotic solution has an important effect on the sensorial and nutritional value of the product.

In case of 0.8±0.1 mm sliced chips, enriched coconut chips has got highest score in colour and appearance, flavor, texture(8.1, 7.5, 7.6) when compared to the control (6.7, 5.3, 6.2). Regarding texture (crispiness) and taste, enriched coconut chips obtained highest score (7.6, 8.3) when compared to the control (6.2, 6.7). The overall acceptability was rated higher in enriched chips of greater score 8 when compared with its control as evaluated with standard protocol of Meilgaard et al. (20).

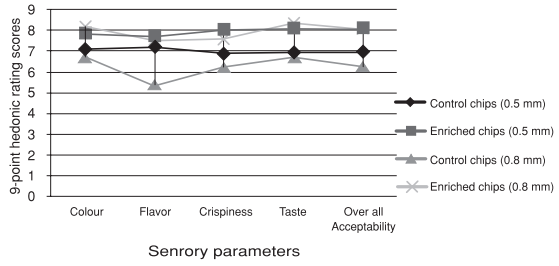

Figure 1. Sensory analysis of the coconut chips

CONCLUSION

The antioxidant rich plant derivatives such as fruits, vegetables, nuts, roots and whole grains synthesize and preserve a variety of biochemical components, many of which are extractable and used for infusion with foods to gain additional nutritional and health benefits which is responsible for eternal health and longevity. The use of beet root extract as an osmotic medium revealed favorable results in nutrient and physical composition with high acceptability sensory score than control coconut chips, can be established as a healthy snack food for all the age groups which complements the food security of the nation.

REFERENCES

1. Kabara JJ. 1978. Fatty acids and derivatives as antimicrobial agents -a review. The Pharmacological Effects of Lipids. Champaign *Am Oil Chem Soc* 75.

2. Loki AL, Rajamohan T. 2003. Hepatoprotective and antioxidant effect of tender coconut water on CCI4 induced liver injury in rats. *Indian J Biochem Biophy*, Vol. 40 (4), 354-357.

3. Rethinam, P. (2004). Exploring emerging business opportunity for coconut products of the Asia and Pacific countries. Asian and Pacific Coconut Community activities, achievements and future outlook. In *Aciar Proceedings* (Vol. 125, p. 15). ACIAR; 1998.

4. Manivannan P, Rajasimman P. 2008. Osmotic dehydration of beetroot in salt solution optimization of parameters through statistical experimental design. *Int J Chem Biomol Eng.* Vol. 1, 214-221.

5. Bchir B, Besbes S, Attia H, Blecker C. 2010. Osmotic dehydration of pomegranate seeds: Mass transfer kinetics and DSC characterization. *Int J Food Sci Tech.* Vol.44, 2208–2217.

6. Spiess WEL, Behsnilian D. 1998. Osmotic treatment in food processing. Current state and future needs. *In Drying* 98, 47-56.

7. Torreggiani D. 1993. Osmotic dehydration in fruit and vegetable processing. *Food Res Int* Vol.26, 59–68.

8. Demirel D. Turhan M. 2003. Air-drying behavior of dwarf Cavendish and gros Michel banana slices. *J Food Eng.* Vol. 59, 1-11.

9. Mavroudis NE, Gekas V, SjohlmI. 1998. Osmotic dehydration of apples, shrinkage phenomena and the significance of initial structure on mass transfer rates. *J Food Eng.* Vol.38, 101–123.

10. Ozen B, Lisa L, Ozdemir M, Floros JD. 2002. Processing factors affecting the osmotic dehydration of diced green peppers. *Int J Food Sci Tech.* Vol. 37, 497–502.

11. Rethinam P, Bosco SJB. 2006. Coconut –Harvest, Processing and Products. *Asian and pacific Coconut Community*, 34.

12. AOAC. 1990. Official methods of analysis of the association of Official Analytical Chemists (15th ed.). Arlington: Association of Official Analytical Chemists, Washington, DC, USA.

13. Grigelmo-Miguel N, Martin-Belloso O. 1999. Characterization of dietary fiber from orange juice extraction. *Food Res Int* Vol. 31, 355–361.

14. Ranganna S.2000. *Handbook of analysis and quality control for fruits and vegetable products*, 2nd ed., Tata McGraw hill publishing co-operation limited, New Delhi. 979-1070.

15. AOAC. 1999. Official methods of analysis of the association of Official Analytical Chemists (14th Ed.). Arlington: Association of Official Analytical Chemists, Washington, DC, USA.

16. Raghuramulu N, Madhavan K, Kalyansundaram S. 2005. Food analysis - *A Manual of Laboratory Techniques*, NIN Press, Hyderabad, 57-8.

17. AOAC. 1995. Official methods of analysis of the association of Official Analytical Chemists (14th Ed.). Arlington: Association of Official Analytical Chemists, Washington, DC, USA.

18. Lawrence Evans Pharmacopeial Forum:Volume No.31 (4), P.1134.

19. Akubugwo IE, Chinyere GC, Ugbogu AE. 2000. Comparative Studies on Oils from Some Common Plant Seeds in Nigeria, *Pak. J. Nutr.* 7 (4), 570-573.

20. Meilgaard M, Civile GV, Carr BT. 1991. *Sensory Evaluation Techniques*, II Edition, 354.

21. Rastogi N, Raghavarao K. 1995. Kinetics of osmotic dehydration of coconut. *J Food Process Eng* Vol. 2 (18), 187-197.

22. Krokida MK, Maroulis ZB. 2000. Effect of drying method on shrinkage and porosity, *Drying Technology*, 15 (10), 2441-2458.

23. Kudra T, Strumillo C. 1998. *Thermal Processing of Bio-materials*, Gordon and Breach Sci Publ., Amsterdam, CRC, The Netherlands, Vol. 10 (2), 669.

24. Imtiaz Hussain M,Iqbal, Iftikhar Shakir, Ayub N. 2004. Effect of Sucrose and Glucose Mixture on the Quality Characteristics of Osmotically Dehydrated Banana Slices. *Pak J Nutr* 3(5), 282-284.

25. Albagnac PG, Varoquaux J, Montigaud CI. 2002. Technologies de transformation des fruits. *Ed. Tec & Doc*, cop. XXII, Paris/Londres/New York, 498.

26. Flink JM. 1980. Dehydrated carrot slices: influence of osmotic concentration on drying behavior and product quality. *J Food Process Eng.* Vol. 1, 412–416.

27. Alzamora SM, Salvatori D, Tapia MS, López-Malo A, Welti-Chanes J, Fito P.2005. Novel functional foods from vegetable matrices impregnated with biologically active compounds, *J Food Eng.* Vol.2 (67), 205–214.

28. Fito P, Chiralt N, Betoret N, Gras ML, Chafer M, Martinez-Monzo J, Andres A, Vidal D. 2001. Vacuum impregnation and osmotic dehydration in matrix engineering. Application in functional fresh food development. *J Food Eng.* Vol.49, 175-183.

29. Jaganathan S, Vijayakumar R, Rahul Gandhi, Ananthi, M., Premkumar A& Charles, C. 2010. Analysis of carbohydrates in newly developed liquid state rabies vaccine. *J Microbial biochem Technol.*Vol.2 (6), 147-151.