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## Development of defatted watermelon seed cake flour (*Citrullus vulgaris*) based RTE extruded snacks

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**Abstract**

Defatted watermelon (*Citrullus vulgaris*) seed cake is an under-utilized by-product of watermelon oil extraction from watermelon seed. The extruded snacks were prepared by addition of defatted watermelon seed cake flour (DWCF) in rice-corn flour blend at 10, 20, 30 and 40% proportions for the preparation of extruded snacks. The optimal level of incorporation of DWCF in extruded snacks was found to be 20% (w/w) upon physical and sensory evaluation of the extrudates at 5% significance level. The proximate composition, mineral and fatty acid profiles were analyzed for control and 20% DWCF incorporated extruded snacks. The extruded snacks prepared using this optimal formulation was packed by nitrogen flushing and studied for properties such as proximate composition, peroxide value, hardness, colour ( $L^*$ ,  $a^*$  and  $b^*$ ) and sensory characteristics during 90 days of storage and compared with control extruded snacks based on rice-corn flour blend. As a result, the DWCF incorporated extruded snacks was found to remain in good condition till the end of storage period.

**Keywords:** Extruded snacks, watermelon, storage study, utilization, defatted, oil seed cake

**1. Introduction**

Ready-to-eat (RTE) snack foods are increasingly popular among consumers predominantly due to consumer appeal factors such as convenience, value, attractive appearance and crispy texture (Harper, 1981) [16]. According to FDA, ready-to-eat food (RTE food) means any food that is normally eaten in its raw state or any other processed food for which it is reasonably foreseeable that the food will be eaten without further processing before consumption. The RTE snack products includes biscuits, crisps, breads, pies, sandwiches and rolls, dairy products (milk, cheese, spreads), prepared salads and vegetables, fruit etc. One of the most important technology for production of RTE snacks is extrusion and these extruded snacks gained interest among the global consumers.

Extrusion technology in food context represents the process of extruding cereal flours under high pressure and temperature through fine pore, due to which plasticized mass enters into atmosphere in expanded form (Korkerd *et al.*, 2016) [22]. Products such as modified cereal flour and starches, textured proteins, snack foods, breakfast cereals and pet foods can be produced using this technique. The development of composite extrudates through the mixture of starchy raw materials with other products like meat, egg, seeds, legumes, fruit waste, etc has been an alternative for obtaining extruded snacks with better sensory, physicochemical and nutritional characteristics (Guy, 2001) [15]. However, addition of high fibre or high protein ingredients to starch significantly affects the texture, expansion and overall acceptability of the extruded snack (Veronica *et al.*, 2006) [27].

Recently more attention has been focused on the utilization of food products and wastes, as well as underutilized agricultural products that are rich in nutritive value. Such utilization would contribute in making use of available resources for new food product formulation which has better nutritional and sensory properties. Watermelon seed is one such underutilized oil seed which has good nutritional mainly protein, mineral and unsaturated fatty acids. The watermelon seed which remain as waste in large quantity after the removal of pulp can be utilized for the production of value added food products as it contains a large quantity of

protein and oil content. India is a major producer of watermelons (*Citrullus vulgaris*) in Asia producing 4,31,930 tons per year and generating 4,320 tons of seeds per year (FAOSTAT, 2017) <sup>[12]</sup>. Though technology exists for decorticating the seeds, only a small portion of this agricultural commodity is commercially processed and majorly utilized for animal feed production. Protein and fat together accounts for 3/4th the weight of the seeds and is grouped under oilseed group, but it has received less attention as an oilseed (Gopalan *et al.*, 1989) <sup>[14]</sup>. Watermelon seed oil has been assessed to contain large amounts of polyunsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA) which are beneficial to human health (El-Adawy and Taha, 2001) <sup>[10]</sup>. It also consists of good amount of minerals like calcium, magnesium, iron and zinc (Jyothi lakshmi and Kaul, 2011) <sup>[21]</sup>.

However, many studies have assessed its use as whole seed in various other food products like cookies, roti, sandesh, laddu, pakoda, toffee, gravy powder and biscuits. Though the watermelon seed are being utilized in some foods and as culinary aids, it is not widely consumed by the population in spite of its high nutritive value. Extrusion technology would be a viable way for making use of this under-utilized watermelon seed. As nutritive extruded snack products are demanded by people across the globe, the nutritive value of watermelon seed can be tapped into extruded snacks.

## 2. Material and Methods

### 2.1 Materials

The dehulled watermelon seed, seasonings and metallized laminate pouches (70µm thickness) were procured from local

market in Chennai. All the reagents used for the chemical analysis of the products were of analytical grade and procured from Merck, India.

### 2.1.1 Preparation of defatted watermelon seed cake flour (DWCF)

Watermelon seed were sundried for 8 hours and were fed into electric ghani fitted with steel pestle and cold-pressed by adding water intermittently up to 10% (weight basis). The separated oil was passed through filter mesh to remove impurities and packed in PET cans. The collected oil was stored at room temperature for further use. The defatted seed cake obtained after extraction was collected and sundried for 8 to 16 hours. The dried seed cake was broken into small pieces using a steel mortar and pestle. The broken seed cakes were milled at local flour mill to obtain fine flour. The flour was sieved for uniform size distribution of 278µm (mesh 45) and packed in polythene bag and stored in cool and dry place.

### 2.1.2 Feed preparation for extrusion

The formulations for the preparation of different extruded snacks namely rice and corn based control extruded snack and DWCF based extruded snacks are shown in Table 1. The rated quantities of rice flour, corn flour and DWCF as discussed in Table 1 were mixed with 3% salt and 8% water. After gentle mixing for 10 minutes, the flour mixture was passed through 2 mm size sieve, to obtain a uniform size mixture. The mix was once again blended for 10 minutes. The resulting flour mix was heaped and covered with polythene sheet for 30 minutes for pre-conditioning before extrusion.

**Table 1:** Formulations used in the development of extruded products

Product (Extruded snacks)	Code	Rice flour (%)	Corn flour (%)	DWCF (%)
Control	C	60	40	-
DWCF based extrudates	D <sub>1</sub>	55	35	10
	D <sub>2</sub>	50	30	20
	D <sub>3</sub>	45	25	30
	D <sub>4</sub>	40	20	40

### 2.1.3 Extrusion cooking

The twin-screw extruder of 15kg/h capacity was used for the preparation of DWCF based extruded snacks. The flour mix was extruded at 110 °C under 400 rpm screw speed through a 4mm die. As the material was extruded, it was cut into pieces of the desired length by a rotating-blade cutter.

### 2.1.4 Packaging and storage

The DWCF incorporated and control extruded snacks were seasoned by spraying 8% (w/w) of watermelon seed oil and sprinkled with seasoning mixture. The seasoned snacks were packed with nitrogen flushing in metallized laminate pouches and stored at room temperature (28-35°C; 60-70% RH) for 90 days.

## 2.2 Determination of Physical properties

### 2.2.1 Expansion ratio

Expansion ratio was measured using vernier caliper as per the method reported by Chinnaswamy and Hanna (1988) <sup>[6]</sup>.

### 2.2.2 Water solubility index (WSI) and water absorption index (WAI)

WSI is used as an index of starch dextrinization and WAI is used as an index of starch gelatinization. WSI and WAI were determined by centrifugation method with distilled water

(Anderson *et al.*, 1982) <sup>[2]</sup>. The percentage of the ratio of dry residue weight to the dry weight of extrudate powder used in the test was taken as water solubility index (WSI). The ratio of the wet weight of centrifuged precipitate to the dry weight of precipitate was taken as the water absorption index (WAI).

### 2.2.3 Colour analysis

Colour of extruded snack products was tested using hunter colorimeter. The colour values of the samples were expressed as L\* (lightness), a\* (redness) and b\* (yellowness).

### 2.2.4 Hardness

Texture profile analysis was conducted using Stable microsystem TA-XT plus texture analyser (Bourne, 1978) <sup>[4]</sup>. The extruded snack samples were compressed twice to form a “two bite” work force compression curve from which hardness (kgf) was determined.

## 2.3 Determination of chemical properties

### 2.3.3 Analysis of proximate composition

The proximate composition of control and DWCF incorporated extruded snack samples were determined in triplicates. Moisture content, crude protein, crude fat, total carbohydrates, total ash and crude fibre were estimated (Horwitz and Latimer, 2000) <sup>[19]</sup>.

### 2.3.4 Analysis fatty acids

The fatty acid profile of the extruded snack products was determined using Gas Chromatography-Mass Spectrophotometer (Horwitz and Latimer, 2000) [19]. The standard fatty acid methyl esters (FAME) solution was added to the powdered samples for direct trans-esterification by dissolution in water. The FAMES were separated from samples using capillary GC. The fatty acids were identified and quantified as PUFA, MUFA and SFA by comparing with the retention time of pure standards.

### 2.3.5 Analysis of minerals

The minerals such as calcium, magnesium, iron and zinc were determined using inductively coupled plasma optical emission spectrometry (ICP-OES) after digestion using nitric and hydrochloric acids (Horwitz and Latimer, 2000) [19].

### 2.3.6 Peroxide value

Peroxide value is an indication of the extent of oxidation suffered by the oil and it was determined by titration method using 0.01 N sodium thiosulphate as stated in AOAC methods (Horwitz and Latimer, 2000) [19]. Peroxide values were expressed as meq/kg.

### 2.4 Determination of sensory characteristics

Experimental samples of extruded snacks prepared during the course of product development and storage study were evaluated for sensory parameters like flavour, colour, appearance, crispiness, texture and overall acceptability using 9 point hedonic scale score card. Twenty five semi-trained panellists from College of Food and Dairy Technology, Chennai were chosen for sensory analysis of all extruded snack samples undertaken in this study.

### 2.5 Statistical analysis

Data were assessed based on the procedures described by Snedecor and Cochran (1994) [26] by analysis of variance (ANOVA) using IBM SPSS program version 20.0 and the means were separated by Duncan's multiple range test with a probability ( $P < 0.01$ ).

## 3. Results and Discussion

### 3.1 Optimization of extruded product incorporated with DWCF

The mean physical parameters such as expansion ratio, bulk density, water absorption index (WAI) and water solubility index (WSI) studied for control and DWCF incorporated extruded snacks were shown in Table 2.

Expansion ratio is one of the key target parameters that can be optimized to achieve the desired sensory properties (Lue *et al.*, 1991) [23]. The expansion ratio of extrudate progressively decreased with the increased incorporation of DWCF. This was due to the incorporation of higher level of DWCF in respective treatments which ultimately increases the protein content and reducing the starch content which affects gelatinization (Bordolai and Ganguly, 2014) [3]. The macro molecular structure of proteins also affects expansion by absorbing large quantities of water in the matrix (Singh *et al.*, 1997) [25]. The statistical analysis revealed that the expansion ratio significantly differed ( $P < 0.01$ ) among different incorporation levels of DWCF. However, duncan test revealed that there was no significant difference ( $P < 0.01$ ) between treatments D<sub>1</sub> and D<sub>2</sub>.

The sensory scores of control and DWCF incorporated snacks are shown in Table 3. The sensory scores of all parameters

showed non-significant difference in DWCF based extruded snacks till the incorporation level of 20% DWCF beyond that there is a drastic reduction in all the sensory parameters for the incorporation of DWCF in extruded snacks. Hence, other treatments were not desired by the panellists due to undesirable appearance, dark colour, poor texture, low crispiness and overall acceptability. The increased addition of protein rich ingredients in extruded snack products prepared using twin-screw extrusion significantly affects the sensory characteristics (Ding *et al.*, 2005) [9]. The statistical analysis revealed that there were significant difference ( $P < 0.01$ ) in all parameters like appearance, colour, flavour, texture, crispiness and overall acceptability among all the treatments incorporated with DWCF and control product. However, there was no significant difference in all parameters among treatments C, D<sub>1</sub> and D<sub>2</sub> according to duncan test.

The study of physical properties indicated that the expansion ratio differed non-significantly between treatments D<sub>1</sub> & D<sub>2</sub> and sensory properties also showed similar results among treatments D<sub>1</sub> & D<sub>2</sub>. So, the treatment D<sub>2</sub> with 20% DWCF was chosen as optimal formulation.

**Table 2:** Physico-chemical properties of DWCF incorporated extruded snacks

Treatments	Physico-chemical properties		
	Expansion ratio	WSI (%)	WAI (g/g)
C	7.723 <sup>a</sup> ±0.07	24.290 <sup>a</sup> ±0.01	6.564 <sup>a</sup> ±0.01
D <sub>1</sub>	6.330 <sup>b</sup> ±0.07	23.318 <sup>b</sup> ±0.06	5.824 <sup>b</sup> ±0.04
D <sub>2</sub>	6.243 <sup>b</sup> ±0.09	23.082 <sup>c</sup> ±0.04	5.618 <sup>c</sup> ±0.07
D <sub>3</sub>	5.334 <sup>c</sup> ±0.09	21.506 <sup>d</sup> ±0.10	5.074 <sup>d</sup> ±0.05
D <sub>4</sub>	5.049 <sup>d</sup> ±0.09	20.914 <sup>e</sup> ±0.11	4.810 <sup>e</sup> ±0.05
F value	608.885**	1420.604**	681.794**

Mean of six replicates, \* ( $P < 0.05$ ); Mean values bearing similar superscripts in a column do not differ significantly

**Table 3:** Sensory characteristics of DWCF incorporated extruded snacks

Treatments	Sensory characteristics					
	Appearance	Colour	Flavour	Texture	Crispiness	Overall Acceptability
C	8.40 <sup>a</sup> ±0.51	8.30 <sup>a</sup> ±0.48	8.20 <sup>a</sup> ±0.63	8.20 <sup>a</sup> ±0.63	8.30 <sup>a</sup> ±0.48	8.20 <sup>a</sup> ±0.63
D <sub>1</sub>	8.10 <sup>a</sup> ±0.56	8.00 <sup>a</sup> ±0.66	8.10 <sup>a</sup> ±0.56	8.00 <sup>a</sup> ±0.66	8.00 <sup>a</sup> ±0.47	8.00 <sup>a</sup> ±0.66
D <sub>2</sub>	7.90 <sup>a</sup> ±0.56	7.80 <sup>a</sup> ±0.63	8.00 <sup>a</sup> ±0.81	7.90 <sup>a</sup> ±0.56	7.70 <sup>a</sup> ±0.67	7.90 <sup>a</sup> ±0.56
D <sub>3</sub>	3.40 <sup>b</sup> ±0.69	3.30 <sup>b</sup> ±0.94	2.90 <sup>b</sup> ±0.99	3.10 <sup>b</sup> ±0.73	3.70 <sup>b</sup> ±0.67	3.20 <sup>b</sup> ±0.78
D <sub>4</sub>	2.30 <sup>c</sup> ±0.94	2.10 <sup>c</sup> ±0.99	1.90 <sup>c</sup> ±0.56	1.90 <sup>c</sup> ±0.73	2.00 <sup>c</sup> ±0.81	1.80 <sup>c</sup> ±0.78
F value	138.278**	114.814**	141.162**	169.426**	157.987**	166.158**

Mean of six replicates, \* ( $P < 0.05$ ); Mean values bearing similar superscripts in a column do not differ significantly

### 3.2 Nutritional characteristics of optimized DWCF based snacks

#### 3.2.1 Proximate composition

The proximate composition of extruded snacks C and D<sub>2</sub> were presented in the Table 4. The comparison of proximate composition between the treatments revealed that the treatment D<sub>2</sub> had higher protein content than C. Similar trend was observed by Nascimento *et al.*, (2012) [24] in the study of incorporation level of defatted sesame seed cake flour in extruded snacks. However, carbohydrate content was higher in control C than treatment D<sub>2</sub>. Since control C was made of rice and corn flour which has large quantity of starch and this



resulted in high carbohydrate content (Ganorkar *et al.*, 2015) [13]. The crude fat content was higher in sample D<sub>2</sub> than control C. This was due to the incorporation of DWCF which has some residual fat remaining. The ash and fibre content was higher in sample D<sub>2</sub> because of DWCF which has high level of total ash (Jyothi lakshmi *et al.*, 2011) [21]. Similar trend was observed by Nascimento *et al.*, (2012) [24] in the study on level of incorporation of defatted sesame seed cake flour in extruded snacks.

**Table 4:** Proximate composition of extruded snacks during storage

Proximate composition (%)	Treatments		F value
	C	D <sub>2</sub>	
Carbohydrate	77.396 <sup>a</sup> ±0.22	62.714 <sup>c</sup> ±0.37	19.756*
Crude protein	8.643 <sup>a</sup> ±0.22	20.270 <sup>c</sup> ±0.56	7217.736*
Crude fat	4.643 <sup>a</sup> ±0.05	6.056 <sup>c</sup> ±0.18	24651.740*
Crude fibre	4.290 <sup>a</sup> ±0.03	5.199 <sup>c</sup> ±0.01	7079.696*
Ash content	2.213 <sup>a</sup> ±0.03	2.576 <sup>c</sup> ±0.04	356.585*
Moisture	2.813 <sup>a</sup> ±0.02	3.183 <sup>a</sup> ±0.05	105.165*

Mean of six replicates, \*(*P* < 0.05); Mean values bearing similar superscripts in a column do not differ significantly

### 3.2.2 Fatty acid composition

The fatty acids composition of extruded snacks control C and D<sub>2</sub> were presented in the Table 5. The saturated fatty acids were higher (*P* < 0.05) in control than D<sub>2</sub>. However, polyunsaturated and monounsaturated fatty acids were higher (*P* < 0.05) in sample D<sub>2</sub> than control. The watermelon seed oil is reported to be composed of 59.99% of PUFA, 18.07% of MUFA and 21.54% of SFA (El-Adawy and Taha 2001) [10]. Since sample D<sub>2</sub> had the highest fat content, PUFA and MUFA content were higher than control. A balanced intake of ω-3 and ω-6 PUFAs is found act as a signalling molecule to protect the brains from preterm, postnatal, and other age-related neurological diseases, such as Alzheimer's disease (Hashimoto *et al.*, 2018) [18].

**Table 5:** Fatty acid profile of extruded snacks during storage

Fatty acids (%)	Treatments		F value
	C	D <sub>2</sub>	
SFA	31.81 <sup>a</sup> ±0.02	31.60 <sup>b</sup> ±0.02	13.265*
PUFA	53.02 <sup>a</sup> ±0.01	53.17 <sup>b</sup> ±0.01	43.756*
MUFA	15.17 <sup>a</sup> ±0.01	15.23 <sup>b</sup> ±0.02	21.131*

Mean of six replicates, \*(*P* < 0.05); Mean values bearing similar superscripts in a column do not differ significantly

### 3.2.3 Mineral composition

The mineral composition of extruded snacks control C and D<sub>2</sub> were presented in the Table 6. The calcium and magnesium were higher (*P* < 0.05) for sample D<sub>2</sub> than control. However, the zinc and iron were found to be slightly higher (*P* < 0.05) in control compared to sample D<sub>2</sub>. The presence of higher levels of calcium and magnesium in treatment D<sub>2</sub> is attributed to the DWCF which has been reported to be rich in minerals (Jyothi lakshmi and Kaul, 2011) [21].

**Table 6:** Mineral composition of extruded snacks during storage

Minerals (mg/100g)	Treatments		F value
	C	D <sub>2</sub>	
Calcium	65.30 <sup>a</sup> ±0.03	164.40 <sup>b</sup> ±0.05	103.294*
Magnesium	162.80 <sup>a</sup> ±0.05	266.01 <sup>b</sup> ±0.04	169.028*
Zinc	18.60 <sup>a</sup> ±0.01	17.80 <sup>b</sup> ±0.03	376.981*
Iron	2.68 <sup>a</sup> ±0.01	2.52 <sup>b</sup> ±0.01	233.615*

Mean of six replicates, \*(*P* < 0.05); Mean values bearing similar superscripts in a column do not differ significantly

## 3.3 Storage study of extruded snacks

### 3.3.1 Peroxide value

The peroxide value of sample D<sub>2</sub> and control increased during storage days as shown in Table 7. The sample D<sub>2</sub> possessed higher peroxide value than control as expected due to increased fat content and its susceptibility to oxidation during extrusion. The processing, storage temperature and porosity of extruded snacks are the main factors which can lead to increased rate of oxidation of oils (Hashempour-Baltork *et al.*, 2017). The peroxide value increased progressively during the storage period however, it was within the permissible limit of <10 meq/kg (I.S. 12566, 1989), hence, the extruded product D<sub>2</sub> was safe to consume till 90 days of storage.

**Table 7:** Peroxide value of extruded snacks during storage

Treatments	Peroxide value (meq/kg)				F value
	0 <sup>th</sup> day	30 <sup>th</sup> day	60 <sup>th</sup> day	90 <sup>th</sup> day	
C	2.308 <sup>a</sup> ±0.08	3.195 <sup>a</sup> ±0.09	4.741 <sup>a</sup> ±0.08	5.979 <sup>a</sup> ±0.10	3390.062*
D <sub>2</sub>	2.316 <sup>a</sup> ±0.12	3.229 <sup>a</sup> ±0.03	4.708 <sup>a</sup> ±0.20	6.024 <sup>a</sup> ±0.06	
F value	705.812*				

Mean of six replicates, \*(*P* < 0.05); Mean values bearing similar superscripts in a column do not differ significantly

### 3.3.2 Moisture

The moisture content of both sample and control increased over the storage period as shown in Table 8. The moisture content was observed to be higher in sample D<sub>2</sub> than control. The increase in moisture may be attributed to the hygroscopic nature of extruded snacks. However, the moisture content of all the extruded snacks was well within the permissible limit of 6% during the storage period (I.S. 12566, 1989).

**Table 8:** Moisture content of extruded snacks during storage

Treatments	Moisture content (%)				F value
	0 <sup>th</sup> day	30 <sup>th</sup> day	60 <sup>th</sup> day	90 <sup>th</sup> day	
C	2.813 <sup>a</sup> ±0.02	3.726 <sup>b</sup> ±0.04	4.540 <sup>c</sup> ±0.05	5.656 <sup>d</sup> ±0.05	3371.703*
D <sub>2</sub>	2.970 <sup>a</sup> ±0.10	3.883 <sup>b</sup> ±0.11	4.696 <sup>c</sup> ±0.12	5.816 <sup>d</sup> ±0.13	
F value	105.165*				

Mean of six replicates, \*(*P* < 0.05); Mean values bearing similar superscripts in a column do not differ significantly

### 3.3.3 Colour analysis

The colour values observed for control and sample D<sub>2</sub> during initial and final days of storage were shown in Table 9. The lightness (L\*) of both control and D<sub>2</sub> reduced while redness (a\*) and yellowness (b\*) values slightly increased during the storage. Similar trend was observed by Alam *et al.*, (2015) [1] in carrot pomace and chick pea incorporated extrudates. Cheng *et al.*, (2011) [7] observed that storage of mung bean snacks had significant effect on color and L\* value was found to decrease with the increase of storage period which is in agreement with present study.

**Table 9:** Colour values of extruded snacks during storage

Treatments	Lightness (L <sup>*</sup> )			Redness(a <sup>*</sup> )			Yellowness(b <sup>*</sup> )		
	0 <sup>th</sup> day	90 <sup>th</sup> day	F value	0 <sup>th</sup> day	90 <sup>th</sup> day	F value	0 <sup>th</sup> day	90 <sup>th</sup> day	F value
C	59.86 <sup>a</sup> ±0.21	57.09 <sup>a</sup> ±0.17	578.10 <sup>*</sup>	11.36 <sup>a</sup> ±0.12	11.81 <sup>a</sup> ±0.12	69.13 <sup>*</sup>	31.71 <sup>a</sup> ±0.12	31.99 <sup>a</sup> ±0.17	18.26 <sup>*</sup>
D <sub>2</sub>	55.48 <sup>c</sup> ±0.72	52.96 <sup>c</sup> ±0.20		12.55 <sup>c</sup> ±0.07	12.93 <sup>c</sup> ±0.18		30.88 <sup>c</sup> ±0.08	31.20 <sup>c</sup> ±0.12	
F value	478.81 <sup>*</sup>			208.48 <sup>*</sup>			57.53 <sup>*</sup>		

Mean of six replicates, \*(*P* < 0.05); Mean values bearing similar superscripts in a column do not differ significantly

### 3.3.4 Hardness

The hardness is an important sensory attribute of an extruded snack which was evaluated during the initial and final days of storage for extruded products C and D<sub>2</sub> as reported in Table 10. The hardness of both control and D<sub>2</sub> extruded snacks tended to decrease during storage due to gain in moisture and

thereby increased starch bonding (Dar *et al.*, 2014) [8]. Similar trend was observed by Alam *et al.*, (2015) [1] in carrot pomace-chick pea based extruded product packed with nitrogen flushing. Charunuch *et al.*, (2008) [5] also reported a decrease in hardness of iron fortified extruded Thai rice snacks stored for four months.

**Table 10:** Hardness values of extruded snacks during storage

Treatments	Hardness (kgf)		F value
	0 <sup>th</sup> day	90 <sup>th</sup> day	
C	3.923 <sup>a</sup> ±0.01	3.375 <sup>a</sup> ±0.01	6236.366*
D <sub>2</sub>	4.471 <sup>c</sup> ±0.02	3.854 <sup>c</sup> ±0.02	
F value	1660.586*		

Mean of six replicates, \*( $P < 0.05$ ); Mean values bearing similar superscripts in a column do not differ significantly

### 3.3.5 Sensory characteristics

The sensory scores of all attributes gradually decreased over the course of storage period but the panellists tended to like both extruded snacks till the end of 90 days of storage (Table 11). The deterioration of appearance and colour was lower during storage in both snacks. The flavour of both extruded snacks was not affected during the storage period. The texture and crispiness of extruded snacks C and D<sub>2</sub> were desirable till the end of 90 days of storage. The overall acceptability of all treatments was above acceptable limit of seven even at end of 90 days of storage. The results are in agreement with Alam *et al.*, (2015) who revealed that the chick pea based extruded snacks packed with nitrogen flushing in metal laminate pouches had good sensory acceptance till the end of 180 day storage.

### 4. Conclusion

Defatted watermelon seed cake is one of the underutilized by-product of watermelon oil extraction which are available at plenty with good nutritional value and health benefits. Extruded snacks are fast moving across the globe preferred by all sections of the population but they are considered as junk food from people point of view. Based on the physico-chemical, textural and sensory characteristics, extruded snacks prepared with 20% DWCF was found to be in good condition with acceptable nutrition, quality and sensory parameters till 90 days of storage at ambient temperature. Hence, utilization of watermelon seed in the production of watermelon seed based extruded snacks through extrusion technology was undertaken and made possible by this research.

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**Table 11:** Sensory characteristics of extruded snacks during storage

Sensory property	Storage days	Treatments	
		C	D <sub>2</sub>
Appearance	0	8.40 <sup>a</sup> ±0.51	7.90 <sup>a</sup> ±0.42
	30	8.10 <sup>ab</sup> ±0.31	7.60 <sup>ab</sup> ±0.42
	60	7.70 <sup>bc</sup> ±0.48	7.40 <sup>ab</sup> ±0.52
	90	7.50 <sup>c</sup> ±0.52	7.10 <sup>b</sup> ±0.67
	F value	16.145*	8.219**
Colour	0	8.30 <sup>a</sup> ±0.48	7.80 <sup>a</sup> ±0.63
	30	8.10 <sup>ab</sup> ±0.56	7.50 <sup>ab</sup> ±0.52
	60	7.70 <sup>bc</sup> ±0.48	7.30 <sup>ab</sup> ±0.48
	90	7.50 <sup>c</sup> ±0.52	7.00 <sup>b</sup> ±0.66
	F value	11.387*	9.357**
Flavour	0	8.20 <sup>a</sup> ±0.63	8.00 <sup>a</sup> ±0.66
	30	8.00 <sup>ab</sup> ±0.66	7.50 <sup>ab</sup> ±0.81
	60	7.70 <sup>ab</sup> ±0.67	7.20 <sup>b</sup> ±0.63
	90	7.50 <sup>b</sup> ±0.52	7.00 <sup>b</sup> ±0.66
	F value	9.605*	10.358**
Texture	0	8.20 <sup>a</sup> ±0.63	7.90 <sup>a</sup> ±0.63
	30	7.90 <sup>ab</sup> ±0.56	7.60 <sup>ab</sup> ±0.51
	60	7.60 <sup>b</sup> ±0.61	7.40 <sup>ab</sup> ±0.69
	90	7.40 <sup>b</sup> ±0.61	7.10 <sup>b</sup> ±0.66
	F value	10.339*	8.842**
Crispiness	0	8.30 <sup>a</sup> ±0.48	7.70 <sup>a</sup> ±0.47
	30	8.10 <sup>a</sup> ±0.61	7.40 <sup>ab</sup> ±0.66
	60	7.80 <sup>ab</sup> ±0.47	7.00 <sup>bc</sup> ±0.56
	90	7.40 <sup>b</sup> ±0.48	6.80 <sup>c</sup> ±0.66
	F value	14.060*	12.379**
Overall acceptability	0	8.20 <sup>a</sup> ±0.48	7.90 <sup>a</sup> ±0.47
	30	7.90 <sup>ab</sup> ±0.51	7.60 <sup>ab</sup> ±0.66
	60	7.60 <sup>bc</sup> ±0.55	7.30 <sup>bc</sup> ±0.47
	90	7.30 <sup>c</sup> ±0.66	7.00 <sup>c</sup> ±0.53
	F value	14.159*	11.547**

Mean of six replicates, \*( $P < 0.05$ ); Mean values bearing similar superscripts in a column do not differ significantly

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