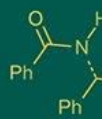


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Studies on physicochemical properties of encapsulated garden cress seed oil cookies

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Abstract

The present research was carried out to evaluate the feasibility of underutilised but nutrient-rich encapsulated garden cress seed oil in cookies. Encapsulated garden cress seed oil incorporated cookies prepared using wheat flour and finger millet flour with 2, 4, 6, 8 and 10% of encapsulated garden cress seed oil powder. The cookies were evaluated for their quality based on proximate analysis, physical properties, textural properties and sensory evaluation during storage. The cookies were packed in Aluminium Laminated Pouches (ALP) for 90 days to study their storage feasibility. The moisture content was found to be increase from 2.55 to 2.98 percent whereas protein content, fat content, ash content and carbohydrates were decreased gradually in the blends fortified with 2, 4, 6, 8 and 10% encapsulated garden cress seed oil powder from 13.64 to 12.34%, 27.65 to 27.02%, 0.69 to 0.59% and 56.80 to 53.60%, respectively during storage. The sensory evaluations of cookies were carried out regularly at an interval of one month for period of 3 months. The cookies prepared by incorporation of garden cress seed oil powder, wheat flour and finger millet flour can be stored up to 3 months in ALP with minimum losses in sensory, nutritional and textural characteristics. The good quality encapsulated garden cress oil powder fortified cookies were prepared at 10 percent in respect of sensory evaluation and physical characteristics and accepted up to three months.

Keywords: Garden cress seed oil powder, cookies, chemical properties, sensory evaluation, storage

Introduction

The demand for processed foods is continually increasing due to the technological, industrial, and economic achievements of developing nations around the world including India Gaikwad *et al.* (2021) [10]. The largest of the processed food businesses, the bakery sector has been expanding gradually throughout the nation. One of the most popular processed convenience foods is cookies. It is a baked food that is small, flat and sweet Yadav *et al.* (2018) [22]. Typically, it includes flour, sugar, and oil or another fat. The ingredients for cookies include sugar, hydrogenated oil, refined flour, and additional ingredients. The majority of components used in commercial cookies are known to be deficient in essential nutrients. Dietary fibre and micronutrients, which are essential components that promote health, lack from refined flour. Trans fats, which are found in hydrogenated fat, have been shown to be harmful to human health Gaikwad *et al.* (2021) [10]. Recognizing the negative health effects of trans fats many countries have banned the trans-fats in foods and have recommended zero tolerance to trans-fats in foods for infants and other vulnerable groups Doke *et al.* (2018) [8]. Nutrition labelling to indicate the trans-fats content is made mandatory in many countries. There is a growing awareness among the consumers regarding the constituents that affect health both positively and negatively. New foods with new health claims are flooding the market to meet the diverse demands of consumers. However, still there is ample scope to enhance the nutritional value of cookies both quantitatively and qualitatively using nutritious food ingredients.

Garden cress is recognised for its pungent odour due to the many volatile oils and was previously used to treat various conditions; respiratory diseases, muscle pain, inflammation, bone fractures Alshehry *et al.* (2019) [4]. For postmenopausal women with cardiovascular disease symptoms such as high blood pressure and cholesterol, regular consumption of

garden cress seed is highly advantageous. Seeds of garden cress have the potential to be a versatile medicinal source Eddouks *et al.* (2005) [9].

There are studies in the literature on the creation of a functional food ingredient using various powdered encapsulated garden cress seed oil. However, no such studies on encapsulated garden cress seed oil powder fortification in bakery products are recorded as far as we know. In order to improve the texture of cookies with health benefits and increased stability, the primary aim of this experiment was to fortify the nutrient content of garden cress seed oil and phenolic compounds from encapsulated garden cress seed oil powder.

Keeping all these reviews in view, an attempt was made to develop nutrient-rich encapsulated garden cress seed oil

cookies and determine its nutritional content and sensory attributes.

Materials and Methods

Ingredients: The major ingredients for the preparation of cookies were encapsulated garden cress seed powder. The wheat flour and finger millet flour were procured from local market.

Treatment details: The encapsulated garden cress seed cookies were prepared by using different levels of encapsulated garden cress seed oil powder with wheat flour and finger millet flour as shown below with constant 50 g vanaspati ghee, 50 g sugar, 0.5 g sodium bicarbonate and 0.5 g ammonium bicarbonate.

Table 1: Treatment details for preparation of encapsulated garden cress seed cookies

Treatments	Treatments combination		
	Wheat flour, g	Finger millet, g	Encapsulated garden cress seed oil powder, g
T ₀	70	30	0
T ₁	69	29	2
T ₂	68	28	4
T ₃	67	27	6
T ₄	66	26	8
T ₅	65	25	10

Methods

Microencapsulation of garden cress seed oil (MGCSO) by spray drying

Encapsulation process of garden cress seed oil was carried out in a laboratory type spray dryer (LU-222 Advanced, Labultima Private Limited, Mumbai, India). In order to investigate the effect of inlet temperature (150–180 °C) and outlet temperature (65–85 °C) of spray drying method, the process conditions were established according to two factorial experimental design. After spray drying process, powder samples were collected from the collector and packed in Aluminium Laminated Pouches and stored in desiccator before further utilization.

Preparation of encapsulated garden cress seed cookies

The cookies were prepared using standard levels of ingredients as per the traditional creaming process.

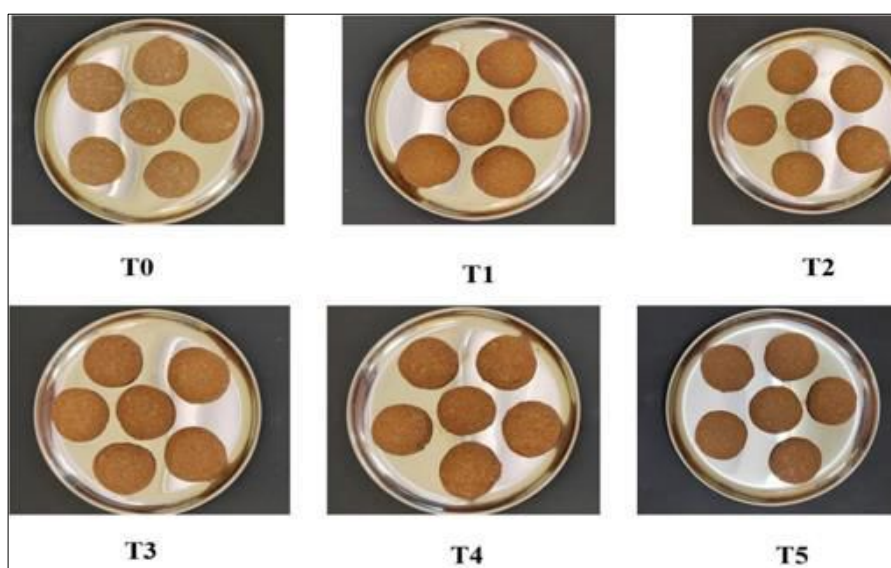
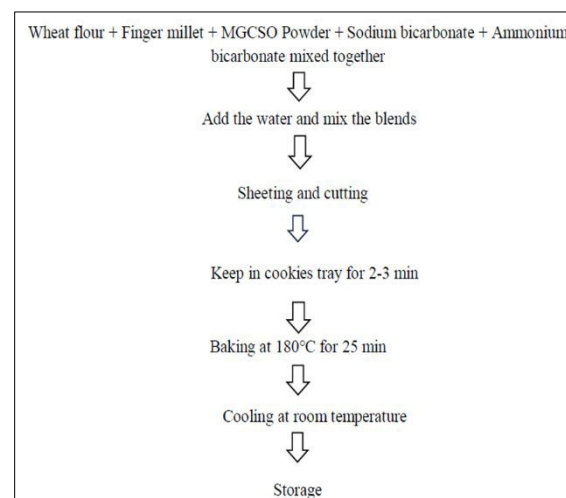


Fig 2: Sample of cookies

Physicochemical analysis of cookies

Physical analysis: The weight, diameter, and thickness of cookies and spread ratio of cookies was calculated by AACC (2000) ^[1] method.

Chemical analysis

The moisture, protein, fat, ash, and carbohydrate content of the cookies were measured using the AOAC 1990 method Shelke *et al.* (2023) ^[23]. Moisture content was determined by oven drying at 105 °C until constant weight was achieved, while protein content was analyzed using the Kjeldahl method. The fat content was quantified through Soxhlet extraction with petroleum ether, and ash content was measured by igniting the samples in a muffle furnace at 550 °C. Carbohydrate content was calculated by difference after subtracting the sum of moisture, protein, fat, and ash from 100%.

Textural analysis of cookies

The texture of the samples was evaluated using a universal testing machine (Model: AG-X, Shimadzu, Japan). A compression test was conducted, and the resulting data were recorded as a force (N) versus time (s) plot. A flat plate probe with a diameter of 36 mm was mounted on a moving crosshead, and the samples were compressed twice to 70% of their original height at a speed of 2 cm/min. All tests were performed at room temperature. The texture profile was assessed using three key parameters: cutting force, crushing force, and penetrating force, which were derived from the texture profile analysis curve Singh *et al.* (1993) ^[20].

Sensory evaluation of cookies

Panellists were selected from the Department of Agricultural Process Engineering, MPKV, Rahuri, based on their prior experience in sensory evaluation of bakery products, specifically cookies. A panel of 15 semi-trained judges was used to evaluate the sensory attributes of the cookies. Sensory evaluation was conducted using a 9-point hedonic scale, where 1 represented "extreme dislike" and 9 represented "extreme like," with intermediate values indicating varying degrees of dislike, neutrality, and like. The judges assessed the cookies for sensory attributes, including colour, taste, aroma, texture, and overall acceptability. All evaluations were conducted in a controlled sensory evaluation room to minimize bias and ensure consistency (Giri *et al.*, 2024 and Kad *et al.*, 2018) ^[27, 28].

Statistical analysis

The data obtained from the different treatments of the study were analyzed using a factorial completely randomized design (FCRD). This design was employed to assess statistical significance and evaluate mean variations. All experiments were performed in triplicate to ensure reproducibility and reliability of the results. The mean values and standard deviations (SD) were calculated using Microsoft Excel Shelke *et al.* (2020) ^[19].

Results and Discussion

Physical characteristics of cookies

The results obtained for physical characteristics of encapsulated garden cress seed oil cookies are presented below:

The results of measurements from the physical characteristics of different cookies made from wheat flour and finger millet fortified with encapsulated garden cress oil powder at 2%, 4%, 8% and 10% levels are presented in Table (1). Weight of the control cookies slightly greater than prepared encapsulated garden cress seed oil cookies with different treatments were 12.63, 12.42, 12.21, 11.82, 11.59 and 11.21 g, respectively. Diameter of the control cookies slightly less than prepared encapsulated garden cress seed oil cookies with different treatments were 44.21, 45.78, 45.26, 46.47 and 46.96 mm, respectively. Thickness of the control cookies slightly greater than prepared encapsulated garden cress seed oil cookies with different treatments were 8.60, 8.23, 7.79, 7.66, 7.62 and 6.74 mm, respectively (Table 1). Spread ratio of the control cookies slightly less than prepared encapsulated garden cress seed oil cookies with different treatments were 5.10, 5.52, 5.77, 6.02, 6.09 and 6.92, respectively.

Table 2: Physical characteristics of cookies

Treatment	Weight (g)	Diameter (mm)	Thickness (mm)	Spread Ratio(D/T)
T ₀	12.63	44.21	8.60	5.104
T ₁	12.42	45.78	8.23	5.525
T ₂	12.21	45.26	7.79	5.772
T ₃	11.82	46.47	7.66	6.029
T ₄	11.59	46.76	7.62	6.098
T ₅	11.21	46.96	6.74	6.928
S.E	0.151	0.324	0.131	0.096
C.D@5%	0.478	1.022	0.414	0.304
CV (%)	1.82	1.020	2.44	2.359

Chemical changes in encapsulated garden cress seed oil cookies during storage

Moisture content is an important quality requirement for product stability and safety, as it determines textural attributes, microbiological development and degradative processes Togay *et al.* (2017) ^[21]. However, cookies' fat and protein content have an impact on their mouth feel and flavour development Yashini *et al.* (2021) ^[23]. The observations of chemical analysis are described in Table 2. Table 2 shows the moisture content of cookies with different concentrations of encapsulated garden cress seed oil powder. During storage, the average value of moisture content increased from 2.25 to 2.74%, 2.29 to 2.85%, 2.38 to 2.83, 2.38 to 2.90%, 2.47 to 2.93% and 2.55 to 2.98% for treatment T₀, T₁, T₂, T₃, T₄ and T₅, respectively. Overall, treatment T₀ consistently showed the lowest moisture content throughout the 90 days storage while, treatment T₅ remained highest. However, moisture content increased remarkably ($p \leq 0.05$) with the concentration of encapsulated garden cress seed oil powder treatments T₁, T₂, T₃, T₄, T₅ and T₆, respectively Previous studies have revealed that the atmosphere or packaging materials can cause cookies to become moist during storage (Pasha *et al.*, 2002 and Butt *et al.*, 2004) ^[15, 6].

Proteins are made up of amino acids linked together by peptide bonds and provide health benefits by lowering the risk of chronic diseases to varying degrees. The data on the changes in cookies during the storage period for different treatments are presented in Table 2. Statistically, storage period and their interaction significantly ($p < 0.05$) affected the protein content of cookies. During storage, the average value of protein content decreased from 11.50 to 11.11%,

11.91 to 11.30%, 12.30 to 11.60, 12.76 to 11.92%, 13.26 to 12.28% and 13.64 to 12.34 for treatment T₀, T₁, T₂, T₃, T₄ and T₅, respectively. At the end of storage, the maximum value of protein content was observed for cookies of treatment T₅ followed by T₄, T₃, T₂, T₁ and T₀. This may be because of reduction in protein content of cookies throughout storage might be due to increasing level of moisture which enhances proteolytic activity. Shelkhe *et al.* (2020) observed that the protein content of jamun powder increased significantly with the storage period.

The ash content of foods shows their mineral content Shelkhe *et al.* (2020) [19]. Minerals make up a small portion of dry matter but play an essential physicochemical and nutritional role. Table 2 shows the ash content of cookies for various treatments. Accordingly, treatment T₀ (control) contained 0.64% ash, while T₅ (MGCSO-10%) had 0.69% ash. During storage, the average value of ash content decreased from 0.64 to 0.53%, 0.65 to 0.55%, 0.65 to 0.56%, 0.66 to 0.57%, 0.67 to 0.58% and 0.69 to 0.59% for treatment T₀, T₁, T₂, T₃, T₄ and T₅, respectively. However, it increased remarkably ($p \leq 0.05$) with the concentration of encapsulated garden cress seed oil powder in the remaining cookies treatments T₁, T₂, T₃, T₄, T₅ and T₆, respectively, which could be attributed to the mineral content of encapsulated garden cress seed oil powder. At the end of storage, the maximum value of ash content was observed for cookies of treatment T₅ followed by T₄, T₃, T₂, T₁ and T₀. Similar results were observed for the ash improvements of cookies containing wheat grass powder. Alshehry *et al.* (2019) [4] revealed a similar increasing trend in ash content for cookies

incorporated with wheat grass powder. It was observed from Table 2 that, the carbohydrate of all cookies decreased as storage period prolongs. Initially, treatment T₀ had the highest carbohydrate as 58.85% followed by treatment T₁, T₂, T₃, T₄ and T₅ as 58.72, 57.94, 57.50, 57.25 and 56.80%, respectively. At 90 days of storage, the trend continued, with treatment T₀ decreasing to 57.37% followed by treatment T₁, T₂, T₃, T₄ and T₅ as 57.30, 56.27, 54.70, 54.40 and 53.60%, respectively. At the end of storage, the maximum value of carbohydrate content was observed for cookies of treatment T₀ followed by T₁, T₂, T₃, T₄ and T₅.

Fat has various roles in the food system, providing additional calories. Food texture, flavour, creaminess, aroma, and palatability are all enhanced by the addition of fat. Food's physical, textural, and sensory qualities are changed when fats are removed, which frequently lowers the food quality and consumer acceptability Yashini *et al.* (2021) [23]. Accordingly, treatment T₀ (control) contained 25.51% ash, while T₅ (MGCSO-10%) had 27.65% ash. During storage, the average value of fat content decreased from 25.51 to 25.25%, 26.17 to 25.18%, 26.43 to 25.95%, 26.75 to 26.16%, 27.55 to 26.58% and 27.65 to 27.02% for treatment T₀, T₁, T₂, T₃, T₄ and T₅ respectively. At the end of storage, the maximum value of fat content was observed for cookies T₅ followed by T₄, T₃, T₂, T₁ and T₀. The reduction in fat content over the course of storage might be caused by the cookies absorption of moisture from the surrounding air and the conversion of lipids into other chemicals Yenge (2017) [24].

Table 3: Effect of storage on chemical properties of cookies

Storage period	Interaction	Moisture Content (%)	Protein Content (%)	Fat content (%)	Ash content (%)	CHO (%)
0 days	S1T ₀	2.25	11.50	25.51	0.64	58.85
	S1T ₁	2.29	11.91	26.17	0.65	58.72
	S1T ₂	2.38	12.30	26.43	0.65	57.94
	S1T ₃	2.38	12.76	26.75	0.66	57.50
	S1T ₄	2.47	13.26	27.55	0.67	57.25
	S1T ₅	2.55	13.64	27.65	0.69	56.80
30 days	S2T ₀	2.31	11.45	25.44	0.60	58.70
	S2T ₁	2.39	11.62	25.88	0.61	58.53
	S2T ₂	2.55	12.16	26.23	0.62	57.74
	S2T ₃	2.59	12.25	26.63	0.62	56.30
	S2T ₄	2.65	13.01	27.03	0.63	55.80
	S2T ₅	2.69	13.30	27.33	0.65	54.94
60 days	S3T ₀	2.57	11.28	25.37	0.56	58.45
	S3T ₁	2.61	11.57	25.75	0.58	58.50
	S3T ₂	2.68	11.75	26.08	0.59	57.60
	S3T ₃	2.84	12.03	26.43	0.61	54.89
	S3T ₄	2.90	12.32	26.78	0.61	54.46
	S3T ₅	2.94	12.52	27.13	0.63	53.88
90 days	S4T ₀	2.74	11.11	25.25	0.53	57.37
	S4T ₁	2.85	11.30	25.18	0.55	57.30
	S4T ₂	2.83	11.60	25.95	0.56	56.27
	S4T ₃	2.90	11.92	26.16	0.57	54.70
	S4T ₄	2.93	12.28	26.58	0.58	54.40
	S4T ₅	2.98	12.34	27.02	0.59	53.60
	SE(m)±	0.02	0.197	0.203	0.009	0.580
	CD@5%	0.06	NS	NS	NS	NS
	CV (%)	1.44	2.816	1.332	2.459	1.773
	S1-0 th Days; S2-30 th Days; S3-60 th Days; S4-90 th Days; T ₀ -Control cookies; T ₁ - 2 gT ₂ - 4 g, T ₃ - 6 g, T ₄ - 8 g, T ₅ - 10 g – Encapsulated Garden cress seed oil powder cookies					

Textural properties of encapsulated garden cress seed oil cookies during storage: The texture of the cookies plays an important role in defining their overall quality. It is a

composite of several factors, such as cutting force, crushing force and penetration force Lashkari *et al.* (2020) [13]. The cutting force, crushing force and penetration force (T₀;

control) were remarkably higher ($p \leq 0.05$) than those of the cookies (T_5). The data presented in Table 4 showed that, the cutting force, crushing force and penetration force of all cookies were found to be decreased during 90 days of storage. During storage, the average value of cutting force decreased from 56.70 to 52.26%, 50.96 to 46.02%, 49.83 to 44.67%, 48.63 to 42.83%, 43.01 to 41.76% and 41.83 to 39.20% for treatment T_0 , T_1 , T_2 , T_3 , T_4 and T_5 , respectively. During storage, the average value of crushing force decreased from 45.28 to 44.90%, 44.62 to 44.41%, 44.32 to 43.68%, 43.67 to 43.45%, 43.15 to 42.50% and 42.70 to 42.38% for treatment T_0 , T_1 , T_2 , T_3 , T_4 and T_5 , respectively.

During storage, the average value of penetration force decreased from 20.79 to 16.22%, 20.68 to 15.79%, 20.15 to 15.02%, 19.78 to 14.98%, 18.42 to 14.22% and 17.88 to 13.89% for treatment T_0 , T_1 , T_2 , T_3 , T_4 and T_5 , respectively. Yenge (2017) [24] observed an increase in moisture content of cookies as a result of atmospheric moisture absorption during storage. This increase in moisture affects the textural characteristics of cookies Romani *et al.* (2016) [16]. Saleem *et al.* (2005) [17] reported decreased in texture during storage. Khuram *et al.* (2014) [12] also found progressive decrease in hardness and physical attributes of biscuits during storage.

Table 4: Effect of storage on textural properties of cookies

Storage period	Interaction	Cutting Force (N)	Crushing Force (N)	Penetration Force (N)
0 days	S1T ₀	56.70	45.28	20.79
	S1T ₁	50.96	44.62	20.68
	S1T ₂	49.83	44.32	20.15
	S1T ₃	48.63	43.67	19.78
	S1T ₄	43.01	43.15	18.42
	S1T ₅	41.83	42.70	17.88
30 days	S2T ₀	54.77	45.15	20.08
	S2T ₁	48.49	44.54	19.62
	S2T ₂	47.92	44.05	19.21
	S2T ₃	47.92	43.60	18.58
	S2T ₄	41.50	42.95	17.69
	S2T ₅	40.64	42.62	16.82
60 days	S3T ₀	52.39	45.07	19.81
	S3T ₁	47.19	44.50	19.12
	S3T ₂	46.16	43.82	18.78
	S3T ₃	43.97	43.50	18.02
	S3T ₄	41.09	42.70	17.41
	S3T ₅	40.01	42.47	16.32
90 days	S4T ₀	52.26	44.90	16.22
	S4T ₁	46.02	44.41	15.79
	S4T ₂	44.67	43.68	15.02
	S4T ₃	42.83	43.45	14.98
	S4T ₄	41.76	42.50	14.22
	S4T ₅	39.20	42.38	13.89
	SE(m)±	0.497	0.252	0.115
	CD@5%	1.377	NS	0.320
	CV(%)	1.861	1.00	1.12
	S1-0 th Days; S2- 30 th Days; S3-60 th Days; S4 – 90 th Days; T ₀ - Control cookies; T ₁ - 2 g T ₂ - 4 g, T ₃ - 6 g, T ₄ - 8 g, T ₅ - 10 g – Encapsulated Garden cress seed oil powder cookies			

Sensory evaluations of encapsulated garden cress seed oil cookies during storage

Sensory appearance is the most important criterion for attractive consumers and indicating product stability during storage. Cookies were evaluated for colour, flavour, texture, and overall acceptability at one-month intervals up to three months of storage. Table 5 shows the average sensory scores of cookies. In this analysis, control treatment (T_0) obtained significantly ($p \leq 0.05$) lower scores on all sensory tests than treatment T_5 because fat enhances colour, taste, texture, and overall (Table 5). The sensory score of all cookies decreased as the storage period increased. It was found that the sensory score of cookies significantly affected by storage ($p < 0.05$).

Sensory score of texture, colour, flavour and taste were found to be decreased from 8.57 to 7.25, 8.52 to 7.82, 8.62 to 7.79 and 8.22 to 7.81, respectively. The colour changes in cookies during storage might have caused by acceleration of Maillard reaction, due to absorption of moisture (Bender, 1996) [5]. Jood *et al.* (2001) [11] and Dayanand *et al.* (2012) [7] reported gradual decrease in colour and appearance of the cookies stored in different packages for 90 days of storage. Nagi *et al.* (2014) found that the increase in moisture of biscuits during storage was caused by the hygroscopic nature of the dried product, the storage environment (temperature, relative humidity), and the type of packaging material.

Table 5: Effect of storage on sensory characteristics of cookies

Storage period	Interaction	Texture	Colour	Taste	Flavour	Overall acceptability
0 days	S1T ₀	7.58	7.59	7.52	7.62	7.42
	S1T ₁	7.83	7.85	7.65	7.81	7.52
	S1T ₂	8.23	8.31	7.74	7.97	7.82
	S1T ₃	8.35	8.41	7.81	8.22	7.93
	S1T ₄	8.43	8.50	7.89	8.37	7.97
	S1T ₅	8.57	8.52	8.22	8.62	8.07
30 days	S2T ₀	7.33	7.39	7.45	7.45	7.32
	S2T ₁	7.58	7.57	7.50	7.66	7.38
	S2T ₂	7.97	8.18	7.61	7.82	7.75
	S2T ₃	8.14	8.27	7.75	7.97	7.77
	S2T ₄	8.23	8.40	7.83	8.06	7.77
	S2T ₅	8.25	8.47	8.01	8.22	7.97
60 days	S3T ₀	7.08	7.27	7.33	7.27	7.21
	S3T ₁	7.38	7.45	7.46	7.58	7.35
	S3T ₂	7.73	8.01	7.53	7.74	7.61
	S3T ₃	7.95	7.97	7.65	7.82	7.68
	S3T ₄	7.81	8.15	7.75	7.97	7.72
	S3T ₅	7.94	8.31	7.92	8.09	7.91
90 days	S4T ₀	6.93	7.25	7.21	7.17	7.18
	S4T ₁	7.16	7.31	7.35	7.37	7.25
	S4T ₂	7.35	7.77	7.46	7.52	7.40
	S4T ₃	7.47	7.58	7.55	7.62	7.66
	S4T ₄	7.44	7.71	7.62	7.75	7.68
	S4T ₅	7.25	7.82	7.81	7.79	7.82
	SE(m)±	0.120	0.088	0.088	0.088	0.088
	CD@5%	NS	NS	NS	NS	NS
	CV (%)	2.685	1.93	1.99	1.956	2.00
	S1-0 th Days; S2-30 th Days; S3-60 th Days; S4-90 th Days; T ₀ -Control cookies; T ₁ - 2 gT ₂ - 4 g, T ₃ - 6 g, T ₄ - 8 g, T ₅ - 10 g–Encapsulated Garden cress seed oil powder cookies					

Conclusion

Cookies were prepared to investigate the acceptability of encapsulated garden cress seed oil in bakery product. Cookies were prepared with different treatment i.e. Control (WF:FM–70:30), T₁(WF:FM: MEGCO-69:29:2), T₂(WF:FM: MEGCO -68:28:4), T₃(WF:FM: MEGCO -67:27:6), T₄(WF:FM: MEGCO -66:26:8) and T₅(WF:FM: MEGCO -65:25:10). Cookies made with encapsulated garden cress seed oil were compared to control cookies in terms of physical, sensory, colour, textural and nutritional properties during storage. Increasing levels of encapsulated garden cress seed oil in cookies reduced their weight and thickness while increasing diameter and spread ratio, indicating improved spreadability with higher fortification levels. During 90 days of storage, cookies fortified with encapsulated garden cress seed oil showed increased moisture, while protein, ash content, carbohydrate, and fat content decreased across all treatments. The changes were most pronounced in cookies with higher levels of fortification, with T₅ (WF:FM: EGCO- 65:25:10) consistently exhibiting the highest nutritional values. The texture of encapsulated garden cress seed cookies deteriorated during 90 days of storage, with decreases observed in cutting, crushing and penetration forces, attributed to increased moisture content from atmospheric absorption. The sensory attributes of encapsulated garden cress seed cookies decreased gradually over 90 days of storage, with higher fat content T₅ (WF:FM: MEGCO -65:25:10) maintaining better scores compared to control T₀ (WF:FM–70:30).

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