

Fortification of functional cookies with *Lepidium sativum* seeds and date powder: Impact on physicochemical, nutritional and antioxidant properties

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Abstract

The present study aimed to evaluate the physico-chemical, nutritional and antioxidant properties of functional cookies enriched with *Lepidium sativum* seeds and date powder. In addition, the incorporation of these ingredients was intended to enhance the nutritional quality and functional value of traditional cookies without affecting the desirable properties. *Lepidium sativum* seeds are rich in dietary fiber, protein, minerals and bioactive compounds, and date powder is a good source of natural sweetness, fiber, essential minerals and phenolic antioxidants. Cookies were prepared with varying degrees of substitution of seed and date powder and analyzed for moisture, ash, protein, fat, crude fiber, carbohydrate content, energy value, mineral composition, total phenolic content, antioxidant activity, texture, color and sensory acceptability. Fortification increased ash, protein, dietary fiber and mineral content compared with the control cookies. The fortified samples also showed increased total phenolic content and antioxidant activity, indicating a higher potential to protect against oxidative stress. Date powder reduced the refined sugar content and imparted desirable color and flavor, while *Lepidium sativum* seeds enhanced the functional and nutritional profile. However, higher levels of substitution may influence texture, spread ratio and sensory attributes. Overall, the results indicated that cookies enriched with *Lepidium sativum* seeds and date powder can be a convenient, nutritious, and antioxidant-rich functional snack with potential health benefits.

How to cite this article: Kamya Patel, Bhavin Soni, Nirali Tank., Fortification of functional cookies with *Lepidium sativum* seeds and date powder: Impact on physicochemical, nutritional and antioxidant properties. *Int J Drug Deliv Technol.* 2026;16(84s):1205-1216. DOI: 10.25258/ijddt.16.84s.130.

Introduction

The development of functional foods is constantly evolving to provide health benefits beyond basic nutrition and to remain suitable for regular dietary consumption (Crowe & Francis, 2013; Granato et al., 2020). This interest is due to consumer demand for more convenient foods with better nutritional quality, dietary fiber, natural antioxidants and plant-derived bioactive compounds. Bakery products especially cookies are good carriers for functional ingredients because of their wide acceptance, long shelf-life, easy preparation and low cost. However, traditional cookies are generally high in refined flour, sugar and fat but low in fiber, minerals and antioxidant compounds. Thus, fortification of cookies with nutrient dense plant ingredients provides an opportunity to improve their nutritional and functional value.

Plant foods have a number of bioactive compounds including phenolic acids, flavonoids, carotenoids and other phytochemicals. These compounds may participate in antioxidant activity by reducing oxidative reactions and scavenging free radicals in experimental systems (Manach et al., 2004; Shahidi & Ambigaipalan, 2015). However, the matrix of the food and thermal processing can influence the stability, extractability and bioavailability of these compounds. Heat-sensitive constituents may be

degraded during baking, or bound phenolics may be released, or antioxidant Maillard reaction products may be generated (Nicoli et al., 1999). Therefore, it is important to study the physicochemical, nutritional and antioxidant characteristics of fortified bakery products after processing.

Garden cress (*Lepidium sativum* L.) is a member of the Brassicaceae family. It has been used traditionally as a food and medicinal plant. The seeds are reported to be a good source of dietary fiber, protein, lipids, minerals and bioactive phytochemicals (Doke & Guha, 2014; Sharma & Agarwal, 2011). Garden cress seeds also include mucilage that can influence hydration, viscosity, dough properties and texture in food products. The seed oil contains nutritionally relevant fatty acids, while the seed contain minerals and antioxidant constituents which may support their use in functional foods (Moser et al., 2009; Zia-Ul-Haq et al., 2012). The incorporation of *Lepidium sativum* seeds into cookies may therefore increase protein, fiber, ash and mineral contents while providing antioxidant activity.

Date fruit (*Phoenix dactylifera* L.) is another potential functional ingredient due to its content of natural sugars, dietary fiber, minerals and phenolic compounds. Dates are considered as a natural source of carbohydrates and sweetness and therefore date

powder could be used as a partial replacement of refined sugar in bakery products (Al-Farsi & Lee, 2008; Karaman & Toker, 2025). Apart from their nutritional significance, dates are also reported to have phenolic acids, flavonoids, carotenoids, tannins and other antioxidant constituents, but their contents differ with cultivar, maturity stage, processing and storage conditions (Baliga et al., 2011; Biglari et al., 2008; Ghnimi et al., 2017). The incorporation of date powder in cookies can improve sweetness, color, flavor, fiber content and antioxidant potential and also reduce the reliance on refined sweeteners.

The enrichment of dietary fiber is of particular interest in the development of cookies, as ingredients rich in fiber can improve the nutritional quality and support desirable physiological functions. The degree of substitution should be carefully optimized, as fiber sources may also influence water absorption, spread ratio, dough consistency, texture and sensory quality (Elleuch et al., 2011). Earlier studies on the addition of fiber- and phenolic-rich ingredients to bakery products have indicated increases in dietary fiber and antioxidant levels, but over-addition may cause harder texture, darker color, reduced spread or lower sensory acceptability (Ajila et al., 2008; Mildner-Szkudlarz et al., 2013; Nandeesh et al., 2010).

A complementary functional cookie formulation of *Lepidium sativum* seeds and date powder may be obtained. Garden cress seeds are a source of protein, fiber, minerals and phytochemicals, and date powder can provide natural sweetness, phenolic compounds, dietary fiber and desirable sensory attributes. Hence, the present study was designed to formulate cookies supplemented with *Lepidium sativum* seeds and date powder and to evaluate their physicochemical properties, proximate composition, antioxidant activity, and sensory acceptability. These products may provide a pragmatic approach for the development of functional snacks with antioxidant richness and consumer acceptability.

Materials and Methods

Materials

They bought refined wheat flour, granulated sugar, shortening, eggs, baking powder, vanilla essence and salt from a local retail market. Mature date fruits (*Phoenix dactylifera* L.) and garden cress seeds (*Lepidium sativum* L.) were purchased from a local supplier. Seeds were cleaned from dust and foreign material, roasted lightly at 120 °C for 5–7 min, cooled down to room temperature and pulverized to a fine powder. Date fruits were de-seeded, dried at 60 °C to constant weight and milled to date powder. Both powders were passed through a 60-mesh sieve,

kept in air-tight containers and stored at 4 °C until use.

The selection of garden cress seed powder was based on its protein, dietary fiber, minerals, lipids and bioactive compounds with antioxidant potential (Sharma & Agarwal, 2011; Zia-Ul-Haq et al., 2012). Date powder was used as a natural sweetening and functional ingredient since dates are a source of carbohydrates, fiber, minerals and phenolic compounds (Al-Farsi & Lee, 2008; Ghnimi et al., 2017).

Formulation of cookies

Five formulations of cookies were made. The control formulation contained 100 % refined wheat flour without garden cress seed and date powder. Wheat flour and refined sugar were partially substituted with garden cress seed powder and date powder in the fortified formulations, respectively. The formulations are as follows.

Treatment	Garden cress seed powder (% of flour)	Date powder (% sugar replacement)
C0 (Control)	0	0
C1	2.5	10
C2	5.0	20
C3	7.5	30
C4	10.0	40

The quantities of shortening, egg, baking powder, vanilla essence, salt and water were constant for all the treatments. Partial replacement was used because high levels of fibre-rich ingredients may affect dough handling, cookie spread, hardness, color and sensory acceptability (Ajila et al., 2008; Mildner-Szkudlarz et al., 2013).

How to Prepare Cookies

Creamed shortening and sugar until a uniform mixture was obtained. Add eggs and vanilla essence and mix well. Refined wheat flour, baking powder, salt, garden cress seed powder and date powder were mixed separately and gradually mixed in the creamed mixture. Water was added as required to form a smooth and workable dough.

The dough was sheeted to a thickness of about 5 mm and cut into circular pieces of uniform diameter. The cookies were baked in a preheated oven at 180 °C for 12–15 min. The cookies were cooled after baking for 30 min at room temperature, then packed in airtight polyethylene bags and stored until analysis. All treatments were prepared in triplicate .

Physicochemical study

The moisture, ash, crude protein, crude fat and crude fiber contents of the cookies were determined using the standard method of the Association of Official Analytical Chemists (AOAC International, 2019). Protein content was calculated by multiplying the nitrogen content by 6.25. Carbohydrate content was determined by difference using the equation:

$$\text{Carbohydrate (\%)} = 100 - [\text{Moisture} + \text{Ash} + \text{Protein} + \text{Fat} + \text{Crude fibre}]$$

The energy value was calculated using Atwater conversion factors:

$$\text{Energy (kcal/100 g)} = [\text{Protein} \times 4] + [\text{Carbohydrate} \times 4] + [\text{Fat} \times 9]$$

The diameter, thickness and spread ratio of the cookie were measured after cooling. The spread ratio was computed as:

$$\text{Spread ratio} = \text{Diameter} / \text{Thickness}$$

Physical characteristics such as spread ratio are important because fiber- and protein-rich ingredients may affect water absorption, gluten development, dough viscosity and cookie texture (Nandeesh et al., 2010).

Total phenolic content determination

The cookie samples were powdered and phenolic compounds were extracted using 80% methanol. Total phenolic content was determined by the Folin–Ciocalteu reagent method of Singleton et al. (1999). Absorbance was read in a spectrophotometer at 765 nm. The standard used was gallic acid and the results were expressed as milligrams of gallic acid equivalent per gram of sample (mg GAE/g).

Assessment of Antioxidant Activity

The antioxidant activity of the cookie extracts was measured by the DPPH free-radical scavenging assay according to Brand-Williams et al. (1995). A known volume of cookie extract was mixed with DPPH solution and left standing for 30 min in dark. Absorbance was recorded at 517 nm. The antioxidant activity was calculated using the equation:

$$\text{DPPH scavenging activity (\%)} = [(A_{\text{control}} - A_{\text{sample}}) / A_{\text{control}}] \times 100$$

Higher inhibition of DPPH is associated with a greater free-radical scavenging activity. The inclusion of garden cress seed and date powder in fortified cookies was expected to increase the antioxidant capacity due to the presence of phenolic compounds and other antioxidant constituents in both ingredients (Baliga et al., 2011; Shahidi & Ambigaipalan, 2015).

Color and Texture evaluation

Cookie color was measured using a colourmeter and expressed as L*, a* and b* values. L* is the lightness, a* is the redness or greenness and b* is the yellowness or blueness. The texture of the cookies was measured by a texture analyzer which measures the breaking force or hardness of the cookies. Date powder was expected to produce darker cookies due to its inherent brown color and the formation of Maillard reaction products during baking. Likewise, the fiber and protein content in garden cress seed powder could increase hardness of the cookies.

Sensory Testing

Sensory evaluation was carried out on the basis of a nine-point hedonic scale, where 1 was “dislike extremely” and 9 was “like extremely”. A semi-trained panel evaluated cookies for color, appearance, aroma, taste, texture, crispness and overall acceptability. Panelists were provided with drinking water to rinse their mouths between samples. Samples were labeled with random 3-digit numbers and presented in random order. All panelists gave their ethical consent to participate.

Statistical Analyzes

All the analyzes were performed in triplicate and the results are expressed as mean ± standard deviation. Data were analyzed by one-way analysis of variance (ANOVA). Tukey’s test was used to compare differences among treatment means at p < .05.

Observation table

1. Colour

Table 1: Frequency and Percentage Analysis on Colour (n = 50 evaluators per group)

Sc ale	Hi gh Fo rti fie d (F	Hi gh Fo rti fie d (	M ed iu m Fo rti fie d (F	M ed iu m Fo rti fie d (	L ow Fo rti fie d (F	L ow Fo rti fie d (	Co ntr oll ed (Fr eq.)	Co ntr oll ed (%)

	re q.)	%)	re q.)	%)	re q.)	%)		
Li ke sli gh tly	18	36	—	—	—	—	—	—
Li ke	18	36	—	—	20	40	—	—
Li ke Ve ry m uc h	14	28	30	60	15	30	19	38
Li ke ex tre m ely	—	—	20	40	15	30	31	62
To tal	50	100	50	100	50	100	50	100

Note: '—' denotes no responses recorded in that category for that group. Scale: Like slightly = Score 6; Like = Score 7; Like Very much = Score 8; Like extremely = Score 9.

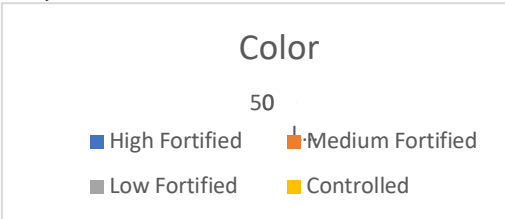


Figure 1: Frequency Distribution of Hedonic Scores for Colour Across Formulation Groups

Table 2: Frequency and Percentage Analysis on Aroma (n = 50 evaluators per group)

Sc ale	Hi gh Fo rti fie d (F re q.)	Hi gh Fo rti fie d (%)	M e d iu m Fo rti fie d (F re q.)	M e d iu m Fo rti fie d (%)	L o w Fo rti fie d (F re q.)	L o w Fo rti fie d (%)	Co ntr oll ed (Fr eq.)	Co ntr oll ed (%)
Li ke sli gh tly	20	40	—	—	—	—	—	—
Li ke	13	26	—	—	15	30	—	—

Li ke sli gh tly	20	40	—	—	—	—	—	—
Li ke	15	30	—	—	18	36	—	—
Li ke Ve ry m uc h	15	30	23	46	16	32	25	50
Li ke ex tre m ely	—	—	27	54	16	32	25	50
To tal	50	100	50	100	50	100	50	100

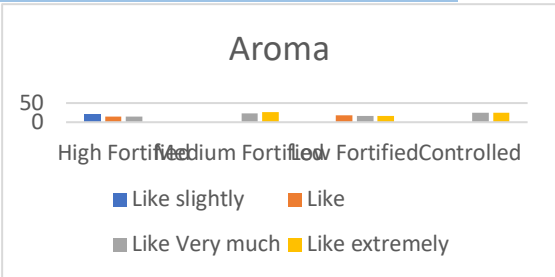


Figure 2: Frequency Distribution of Hedonic Scores for Aroma Across Formulation Groups

Table 3: Frequency and Percentage Analysis on Taste (n = 50 evaluators per group)

Sc ale	Hi gh Fo rti fie d (F re q.)	Hi gh Fo rti fie d (%)	M e d iu m Fo rti fie d (F re q.)	M e d iu m Fo rti fie d (%)	L o w Fo rti fie d (F re q.)	L o w Fo rti fie d (%)	Co ntr oll ed (Fr eq.)	Co ntr oll ed (%)
Li ke sli gh tly	20	40	—	—	—	—	—	—
Li ke	13	26	—	—	15	30	—	—

Like Very much	17	34	31	62	19	38	20	40
Like extremely	—	—	19	38	16	32	30	60
Total	50	100	50	100	50	100	50	100

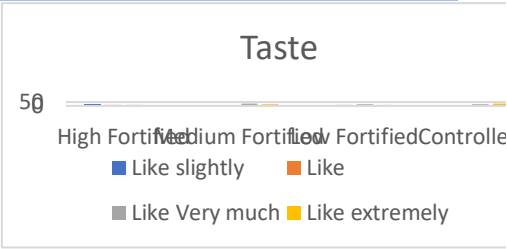


Figure 3: Frequency Distribution of Hedonic Scores for Taste Across Formulation Groups

Table 4: Frequency and Percentage Analysis on Texture (n = 50 evaluators per group)

Scale	High Fortified (Freq.)	High Fortified (%)	Medium Fortified (Freq.)	Medium Fortified (%)	Low Fortified (Freq.)	Low Fortified (%)	Controlled (Freq.)	Controlled (%)
Like slightly	19	38	—	—	—	—	—	—
Like	15	30	—	—	12	24	—	—
Like Very much	16	32	28	56	17	34	20	40

Like extremely	—	—	22	44	21	42	30	60
Total	50	100	50	100	50	100	50	100

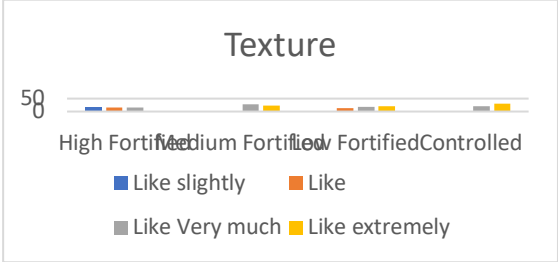


Figure 4: Frequency Distribution of Hedonic Scores for Texture Across Formulation Groups

5 Overall Acceptability

Table 5: Frequency and Percentage Analysis on Overall Acceptability (n = 50 evaluators per group)

Scale	High Fortified (Freq.)	High Fortified (%)	Medium Fortified (Freq.)	Medium Fortified (%)	Low Fortified (Freq.)	Low Fortified (%)	Controlled (Freq.)	Controlled (%)
Like slightly	12	24	—	—	—	—	—	—
Like	18	36	—	—	15	30	—	—
Like Very much	20	40	27	54	19	38	21	42

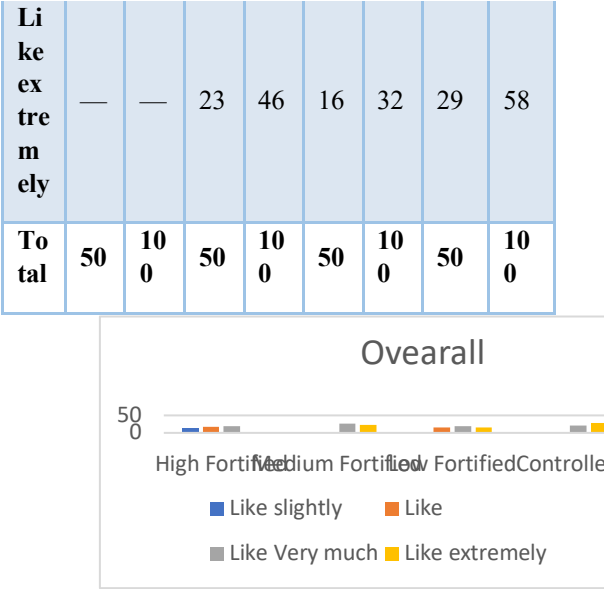


Figure 5: Frequency Distribution of Hedonic Scores for Overall Acceptability Across Formulation Groups

Table 6: Descriptive Statistics for All Quality Parameters Across Formulation Groups (N = 50)

Formulation Group	Moisture (%)	Water Activity	Hardness (N)	L* (Lightness)	a* (Redness)	b* (Yellowness)	TPC (mg/g)	DPPH Scavenging (%)	Overall Acceptability
Control	6.58 ± 0.05	0.407 ± 0.005	34.78 ± 0.3	61.46 ± 2.76	5.82 ± 1.33	22.33 ± 1.96	2.73 ± 0.36	47.25 ± 2.28	7.19 ± 0.52
Low Fortification	6.41 ± 0.05	0.44 ± 0.00	37.07 ± 0.5	63.7 ± 0.4	5.96 ± 1.6	23.1 ± 1.5	2.7 ± 0.2	46.8 ± 0.0	7.25 ± 0.14

	98	31	74		11		22		
Medium Fortification	6.43 ± 0.04	0.41 ± 0.02	34.7 ± 0.5	61.9 ± 2.81	5.94 ± 1.3	22.3 ± 1.5	2.7 ± 0.5	49.16 ± 0.35	7.37 ± 0.88
High Fortification	6.55 ± 0.07	0.42 ± 0.03	36.1 ± 0.8	62.5 ± 3.88	5.9 ± 1.3	21.7 ± 0.57	2.9 ± 0.42	50.3 ± 0.9	7.52 ± 0.57

Table 7: One-Sample t-Test for Control Group (Test Value = 0, df = 15)

Parameter	t	df	Sig. (2-tailed)	Mean Difference	95% CI Lower	95% CI Upper
Moisture (%)	52.655	15	0	6.58688	6.3202	6.8535
Water Activity	63.071	15	0	0.40731	0.3935	0.4211
Hardness (N)	31.852	15	0	34.78125	32.4538	37.1087
L* (Lightness)	88.954	15	0	61.4625	59.9898	62.9352
a* (Redness)	18.803	15	0	5.82625	5.1658	6.4867
b* (Yellowness)	57.148	15	0	22.3375	21.5044	23.1706

TPC (mg GAE/g)	32.516	15	0	2.735	2.5557	2.9143
DPPH Scavenging (%)	36.434	15	0	47.625	44.8389	50.4111
Overall Acceptability	50.298	15	0	7.19375	6.8889	7.4986

Table 8: One-Sample t-Test for Low Fortification Group (Test Value = 0, df = 11)

Parameter	t	df	Sig. (2-tailed)	Mean Difference	95% CI Lower	95% CI Upper
Moisture (%)	37.113	11	0	6.41417	6.0338	6.7946
Water Activity	46.106	11	0	0.4235	0.4033	0.4437
Hardness (N)	22.24	11	0	37.075	33.4058	40.7442
L* (Lightness)	51.579	11	0	63.70083	60.9826	66.4191
a* (Redness)	12.821	11	0	5.96333	4.9396	6.9871
b* (Yellowness)	40.753	11	0	23.12417	21.8753	24.3731
TPC (mg GAE/g)	42.9	11	0	2.76083	2.6192	2.9025
DPPH Scavenging (%)	24.863	11	0	46.8	42.657	50.943
Overall Acceptability	60.589	11	0	7.25	6.9866	7.5134

Table 9: One-Sample t-Test for Medium Fortification Group (Test Value = 0, df = 12)

Parameter	t	df	Sig. (2-tailed)	Mean Difference	95% CI Lower	95% CI Upper
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			tail ed)		Lo wer	Upp er
Moisture (%)	57.435	12	0	6.43077	6.1868	6.6747
Water Activity	53.118	12	0	0.41962	0.4024	0.4368
Hardness (N)	27.637	12	0	34.7	31.9644	37.4356
L* (Lightness)	79.535	12	0	61.99846	60.3	63.6969
a* (Redness)	16.692	12	0	6.04385	5.2549	6.8327
b* (Yellowness)	62.076	12	0	22.30154	21.5188	23.0843
TPC (mg GAE/g)	34.526	12	0	2.91692	2.7328	3.101
DPPH Scavenging (%)	29.271	12	0	49.4	45.7228	53.0772
Overall Acceptability	29.92	12	0	7.37692	6.8397	7.9141

Table 10: One-Sample t-Test for High Fortification Group (Test Value = 0, df = 11)

Parameter	t	df	Sig. (2-tailed)	Mean Difference	95% CI Lower	95% CI Upper
Moisture (%)	32.102	11	0	6.56	6.1102	7.0098
Water Activity	50.782	11	0	0.4225	0.4042	0.4408
Hardness (N)	32.981	11	0	35.575	33.2009	37.9491
L* (Lightness)	60.547	11	0	62.525	60.2521	64.7979

a* (Redness)	15.419	11	0	6.19083	5.3071	7.0745
b* (Yellowness)	30.35	11	0	21.68167	20.1093	23.254
TPC (mg GAE/g)	26.555	11	0	2.84667	2.6107	3.0826
DPPH Scavenging (%)	31.469	11	0	50.20833	46.6967	53.7199
Overall Acceptability	45.197	11	0	7.36667	7.0079	7.7254

Table 11: Pearson Correlation Matrix Control Group (n = 16) (* p < 0.05; ** p < 0.01; shading indicates r ≥ 0.40 and r ≥ 0.60)

	Moi st. %	Wat. Act.	Hardness	L*	a*	b*	TPC	DPPH %	OA
Moi st. %	1	0.174	0.395*	0.29	0.043	0.025	0.145	0.121	0.352
Wat. Act.	0.174	1	0.141	0.022	0.229*	0.138	0.207	0.121	0.236
Hardness	0.395*	0.141	1	0.018	0.033	0.17	0.543*	0.044	0.317*
L*	0.29	0.022	0.018	1	0.358*	0.34*	0.234*	0.346*	0.297*
a*	0.043	0.229*	0.033	0.358*	1	0.057	0.088	0.045	0.091

b*	0.025	0.138	0.17	0.304*	0.057	1	0.039	0.246*	0.04
TPC	0.145	0.207	0.543*	0.234*	0.088	0.039	1	0.085	0.035
DPPH %	0.121	0.121	0.044	0.346*	0.045	0.246*	0.085	1	0.338*
OA	0.352	0.236	0.317*	0.297*	0.091	0.045	0.035	0.338*	1

Table 12: Pearson Correlation Matrix Low Fortification Group (n = 12) (* p < 0.05; ** p < 0.01)

	Moi st. %	Wat. Act.	Hardness	L*	a*	b*	TPC	DPPH %	OA
Moi st. %	1	0.3	0.395*	0.178	0.119	0.497*	0.159	0.262	0.464*
Wat. Act.	0.3	1	0.084	0.055	0.134	0.209	0.125	0.018	0.068
Hardness	0.395*	0.084	1	0.025	0.175	0.273	0.221	0.355*	0.419*
L*	0.178	0.055	0.025	1	0.262*	0.175	0.495*	0.051	0.331*

a*	0.199	0.134	0.175	0.262*	1	0.017	0.185	0.282	0.2
b*	0.497*	0.209	0.273	0.175	0.017	1	0.405*	0.004	0.392*
T P C	0.159	0.125	0.212	0.495*	0.185	0.405*	1	0.237	0.156
D P P H %	0.262	0.018	0.355*	0.051	0.082	0.044	0.237	1	0.318*
O A	0.464*	0.068	0.419*	0.331*	0.223	0.392*	0.156	0.318*	1

Table 13: Pearson Correlation Matrix for Medium Fortification Group (n = 13) (* p < 0.05; ** p < 0.01)

	Moi st. %	W at. Ac t.	H ar dn es s	L *	a *	b *	T P C	D P P H %	O A
Moi st. %	1	0.039	0.211	0.319*	0.03	0.212	0.076	0.127	0.127
W at. Ac t.	0.039	1	0.019	0.131	0.025	0.237	0.067	0.266	0.266
H ar dn es s	0.211	0.019	1	0.233	0.390*	0.068	0.293*	0.125	0.065

L*	0.319*	0.131	0.233	1	0.024	0.518*	0.072	0.049	0.216
a*	0.03	0.025	0.390*	0.024	1	0.501*	0.074	0.089	0.105
b*	0.212	0.237	0.068	0.518*	0.501*	1	0.109	0.455*	0.311*
T P C	0.126	0.027	0.293*	0.072	0.074	0.109	1	0.311*	0.493*
D P P H %	0.071	0.06	0.125	0.049	0.089	0.455*	0.311*	1	0.153
O A	0.127	0.266	0.065	0.216	0.105	0.311*	0.493*	0.153	1

Table 14: Pearson Correlation for Matrix High Fortification Group (n = 9) (* p < 0.05; ** p < 0.01)

	Moi st. %	W at. Ac t.	H ar dn es s	L *	a *	b *	T P C	D P P H %	O A
Moi st. %	1	0.113	0.026	0.017	0.045	0.641*	0.122	0.363*	0.363*
W at. Ac t.	0.113	1	0.361*	0.544	0.812	0.426*	0.322	0.277	0.277

				*	*	*			
H ar dn es s	0. 02 6	0. 36 1*	1	0. 0 3 4	0 . 1 8 4	0. 3 8 3 *	0. 1 9 5	0. 12 8	0. 4 6 0 *
L*	0. 01 7	0. 54 4*	0. 03 4	1	0 . 4 2 9	0. 4 5 6 *	0. 2 4 8	0. 34 1*	- 0. 0 6 2
a*	0. 04 5	0. 19 3	0. 18 4	0. 4 2 9	1	0. 2 3 2	0. 2 8 6	- 0. 16 1	0. 2 4 8
b*	0. 49 2	0. 81 2*	0. 38 3*	0. 4 5 6 *	0 . 2 3 2	1	0. 0 6 6	0. 02	0. 0 3 3
T P C	0. 64 1*	0. 42 6*	0. 19 5	0. 2 4 8	0 . 2 8 6	0. 0 6 6	1	0. 37 7*	0. 7 3 2 *
D P P H %	0. 12 2	0. 32 2	0. 12 8	0. 3 4 1 *	- 0 . 1 6 1	0. 0 2 1	0. 3 7 7 *	1	0. 0 7 3
O A	0. 36 3*	0. 27 7	0. 46 0*	- 0. 0 6 2	0 . 2 4 8	0. 0 3 3	0. 7 3 2 *	0. 07 3	1

Discussion

All the four sections sensory frequency analysis, descriptive statistics, one sample t-tests and correlation analysis show a clear and consistent complementary continuity of the role played by seed flour of garden cress and dried dates powder fortification in the quality of sugar-free and gluten-free multigrain cookies. Taken together the results lead to three primary findings.

Firstly the level of sensory acceptability was improved significantly in comparison to a fortification level. The frequency analysis revealed

that the overall mean scores for acceptability were increasing steadily with Control (7.193) as the median score followed by Low Fortification (7.250), Medium Fortification (7.376) and finally with the High Fortification (7.522) with all four groups (at the highest level) scoring above the 7.0 Hedonic threshold. This trend was confirmed statistically by the t-test analysis: The High Fortification had the highest overall acceptability ranging CI (7.008-7.725) which confirms that high-level holistic consumer liking is not just an artifact of the sampling result but a statistically significant characteristic of these cookies. The Medium Fortification was the best formulation in terms of the individual attributes with 100 percent of the evaluators giving 8 or 9 for aroma and texture and equivalent taste scores to the wheat-sucrose Control, hence the best formulation in a consumer product that has both celiac and diabetic consumers. However, when considering the individual attribute scores, High Fortification received the highest overall holistic liking, suggesting it is the option of choice for consumers with a particular interest in a unique functional flavor profile.

Secondly, the antioxidant and phenolic enrichment were dose dependent and statistically valid at Medium Fortification level. The descriptive statistics showed that TPC and DPPH were increasing, from Control to the Medium and High Fortification. The t-test CI analysis has provided the quantitative statistical validation. The TPC CIs lower bounds for Medium Fortification (2.733 mg GAE/g) and High Fortification (2.611 mg GAE/g) are higher than the Control t-test CI lower bound (2.556 mg GAE/g) and the DPPH CIs of both. The correlation test showed the important result that the relationship in overall acceptability of TPC which was insignificant ($r = 0.035$) in Control group, was significant ($r = 0.493$) in Medium Fortification and significant ($r = 0.732$) in High Fortification. This gradual improvement suggests that GCS phenolics, with increasing doses, move from being available to the nutritional but undetectable sensorially to active contributors of sensory elements that are found and responded to in a positive manner of the study by the evaluators and that had direct practical significance to the functional food development goal of the study.

Thirdly, all physicochemical formulations were kept. All groups showed very similar p-values of narrow t-test confidence intervals and moisture content and water activity data through the descriptive statistic and narrow ranges. The key physicochemical result is the texture of the multigrain gluten-free base, which is mean hardness with the 95% CIs overlapping identically (31.964-37.436 N and 32.454-37.109 N). The texture of Medium Fortification and Control is similar, between 34.700 N and 34.781 N. The correlation

analysis supported this as hardness and acceptability of overall relationships were significant in both Control ($r = 0.317$) and Low Fortification ($r = 0.419$) condition suggesting that textual firmness is consistently a strong predictor of consumer liking regardless of the formulation and maintaining this property in the gluten free versions was a successful formulation accomplishment.

The combined findings demonstrate beyond reasonable doubt that the Medium Fortification is the best balanced formulation that tastes the same as the Control, has statistically improved phenolics addition over the Control, matches hardness as the Control, and is universally aroma and texture acceptable. High Fortification has the highest overall consumer liking and antioxidant capacity, but lower individual attribute scores, thus most suitable for consumers who prefer unique functional flavor profiles. Both Medium and High Fortification achieved main goals of study, to prepare gluten free, sugar free, multigrain cookies with demonstrably better nutritional and antioxidant property than conventional cookies with sucrose and wheat and to gain high acceptance by the majority of consumers.

Conclusion

This study shows that fortification of gluten-free, sugar-free multigrain cookies with *Lepidium sativum* seeds and date powder could enhance their functional value, while preserving the desirable physicochemical and sensory characteristics. The fortified cookies showed higher total phenolic content and antioxidant activity than the control formulation. The highest antioxidant response was obtained at higher fortification levels. The formulations were similar in moisture, water activity and hardness, suggesting that fortification did not adversely impact the product stability and texture.

The medium-fortified formulation exhibited the most balanced overall performance among the tested samples. It was well accepted by the consumers for color, aroma, taste and texture with higher phenolic content and antioxidant activity and hardness similar to control. The high fortified formulation had the highest overall acceptability score and antioxidant activity which makes it suitable for consumers preferring a more unique functional flavor profile.

To summarize, *Lepidium sativum* seeds and date powder are promising ingredients for the development of nutrient-dense functional cookies of acceptable sensory quality. Medium fortification is recommended as the optimum formulation as it provides the best balance between consumer acceptability, texture and antioxidant enhancement. Further studies should be performed to evaluate

shelf life, detailed bioavailability of nutrients and the potential health effects of the product in target consumer groups.

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