Original Research Article

Oilseed Meals An Untapped Resource for Nutritional Innovation

Abstract: The present investigation was carried out to nutritionally evaluate *laddo* supplemented with oilseed meals, including sesame meal (SM), flaxseed meal (FM), and groundnut meal (GM) at three level of incorporation (12, 18, and 24 %). Composite meal was also prepared by mixing sesame, flaxseed & groundnut meal in equal amounts for the development of *laddo* similarly at three levels of incorporation (12, 18, and 24 %). All the developed *laddo* were found to be organoleptically acceptable adjudicated by nine point hedonic scale. Acceptability scores of all kinds of *laddo* varied between 'liked moderately' to 'liked very much' category. *Laddo* with 24 % of incorporation of oilseed meal were studied for nutritional composition. Corresponding *laddo* prepared without oilseed meal was taken as control. Incorporation of all the three oilseed meals individually and in combination resulted in significant improvement in level of crude protein, fat, ash, and crude fiber, which ranged from 13.35-20.03, 25.52-35.99, 3.97-5.70, 4.19-5.14 %, respectively. One serving (25gm) of *laddo* can meet 27% requirement of protein for pre-schoolers as per RDA (Recommended Dietary Allowances) 2020. Value added *Laddo* if promoted and popularized will help in the utilization of oilseed meals which are generally discarded and have a great nutritive potential which can be

used for enrichment of daily diet at a reasonable cost. The developed recipe can be efficiently used as a means of improving nutritional status and to eliminate the malnutrition.

Keywords: Oilseed meals, *Laddo*, and Malnutrition.

1. Introduction:

After the extraction of oil from oilseeds, the residue (by-products of oil extraction) is obtained. Those residues are known as oilseed meal/oilseed cake which are used as fodder or are discarded as waste. From one ton of oilseed approx. 500 to 650 kilos of the meal is obtained depending on the type of oilseed and as by practice half of the oilseed cake received from the production is being dissipated. Oilseed meals are nutritionally rich and major sources of protein, fatty acids, polyphenols, and dietary fibre. There are several oilseed meals available like rape & mustard seed meal, sesame seed meal, flaxseed meal, groundnut seed meal, etc. All these are nutrient-dense and very economical and can be used to develop human foods that can be directly consumed (Karnika *et* al. 2022).

Peanut also known as groundnut (Arachis hypogaea) is a legume crop grown mainly for its edible seeds. Due to its high oil content, it is classified as a grain and legume and an oil crop (Dwiwedi *et* al. 2011*)*. Peanut flour obtained after dehulling and grinding contained 49.97 % crude protein, 2.80 % crude fiber, 3.50 % ash and 27.54 % fat (Park *et* al. 2017).

Flaxseed (*Linum usitatissimum*) also known as linseed, is a flowering plant in the family of Linaceae. After the oil extraction flaxseed meal is obtained which is protein-rich and can be used in different ways for human use. This meal is rich in vitamin B_6 and contains fiber up to 2-7 %. Vitamin B6 is an essential nutrient which body uses as a coenzyme in some 100s of enzymatic reactions in the human body (Heuze *et* al. 2017).

Sesame (*Sesamum indicum*) is a flowering plant in the genus *Sesamum*, also known as *benne* (*Merriam-Webster.com 2021).* Sesame oil meal is a protein-rich by-product. Expeller sesame

meal has a protein content of about 45 % and ranging from 32 to 53 % whereas solvent extracted sesame meal contains about 48 % protein (Karnika *et* al. 2022).

Considering the nutritional potential of selected oilseed meals which are otherwise discarded as waste, present investigation was carried out to develop nutrient dense *laddo* which can be made easily and popularized among all age groups. The value added *laddo* can be used for enrichment of daily diet which can be helpful for improving nutritional status of community and may contribute to eradicate problem of malnutrition.

2. MATERIALS AND METHODS

Present study was carried out in Department of Foods and Nutrition, I.C. College of Home science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Sesame and peanut meal was procured from the local market and flaxseed meal (cold pressed) was procured from India mart.

The required ingredients for the preparation of *Laddo* namely, whole wheat flour, ghee, refined sugar, peanut & sesame were purchased in a single lot from the local market of Hisar.

2.1 Product Development

A spherical treat from the Indian subcontinent, *laddu* or *laddo* is created with a variety of ingredients and either sugar syrup or jaggery. According to some, it's "possibly the most ancient and universal of Indian sweets (*The Bloomsbury Handbook of Indian Cuisine* 2023).

Twelve types of *laddo* were prepared by replacing whole wheat flour at 12 (T1& C1), 18 (T2 & C2) and 24 (T3 & C3) % of wheat flour by sesame meal, peanut meal, flaxseed meal and composite meal (prepared by mixing sesame, flaxseed and groundnut meal in equal amount) individually (Table 1). Corresponding *laddo* prepared without addition of oilseed meals were served as control. For the control laddo, standard recipe ingredient proportions of wheat flour,

ground sugar, ghee, roasted sesame seeds, and roasted peanut were 50g, 30g, 30g, 15g, and 25g, respectively. Wheat flour and oilseed meal powder was sieved separately and oilseed meal was dry roasted whereas wheat flour was roasted in ghee. After roasting of wheat flour and oilseed meals, roasted and crushed peanut and sesame were added to the mixture and removed from fire. Ground sugar was added after mixture was slightly cooled down. Balls were prepared from the mixture.

Table 1: Types of *laddo*

Incorporated recipe	Types of *laddo*	Level of incorporation
Control	control	Whole wheat flour::100
Sesame meal	T1	Whole wheat flour:SM::88:12
	T2	Whole wheat flour:SM::82:18
	T3	Whole wheat flour:SM::76:24
Flaxseed meal	T1	Whole wheat flour:FM::88:12
	T2	Whole wheat flour:FM::82:18
	T3	Whole wheat flour:FM::76:24
Groundnut meal	T1	Whole wheat flour:GM::88:12
	T2	Whole wheat flour:GM::82:18
	T3	Whole wheat flour:GM::76:24
Composite meal	C1	Whole wheat flour:CM::88:12
	C2	Whole wheat flour:CM::82:18
	C3	Whole wheat flour:CM::76:24

Control- without any oilseed meal incorporation (T1, T2 and T3 are 12%, 18%, and 24%).

2.2 Organoleptic Evaluation

Organoleptic evaluation of supplemented oilseed meal *Laddo* adjudicated using nine point hedonic rate scale by a panel of ten semi-trained judges from I.C College of Home Science, CCS Haryana Agricultural University, Hisar. The judges were presented with each oilseed meal *laddo* at separate time session along with control. Organoleptic evaluation were made with respect to color, appearance, aroma, texture, and taste on a scale of one to nine representing ‘dislike extremely’ to ‘like extremely’ categories. The scale of five represented the neutral score ‘neither like nor dislike’.

2.3 Nutritional Evaluation

Moisture, ash, crude fat, crude protein, and crude fiber were estimated using the standard analysis methods (AOAC, 2010).

2.4 Statistical analysis

The data obtained from nutritional analysis and organoleptic evaluation was statistically analyzed using mean, standard error, and ANOVA (one-way and two-way analysis). Replicates were used for experiments. The level of significance was set at P≤0.05.CD (Critical difference) was used to check the significance of the results (Sheoran and Pannu, 1999).

3. Results and Discussion

3.1 Organoleptic acceptability- *Laddo* developed from oilseed meals were found organoleptically acceptable by panel of judges. *Laddo* prepared without oilseed meal served as control. The mean acceptability scores of control *laddo* were 8.87, 8.70, 8.70, 8.50, 8.63, and 8.68 for color, appearance, aroma, texture, taste, and overall acceptability, respectively (Table 2).

3.2 Sesame meal *laddo*: The mean acceptability scores for color, appearance, aroma, texture and taste were ranged from 8.33 to 8.38, 8.10 to 8.40, 8.09 to 8.26, 7.91 to 8.00, and 8.18 to 8.30, respectively. Results elucidates that overall acceptability scores for T1, T2 and T3 *laddo* were 8.27, 8.21, and 8.12, respectively. The taste, texture, appearance, and overall acceptability of all sesame meal *laddo* were ranged from 'liked moderately' to 'liked very much' category and control *laddo* sensory attributes lied in 'liked very much' category (Table 2).

3.3 Flaxseed meal *laddo*: The mean acceptability scores for developed *laddo* ranged between 8.34 to 8.48, 8.20 to 8.60, 8.12 to 8.40, 7.88 to 8.04 and 8.04 to 8.23 for color, appearance, aroma, texture and taste, respectively. Overall acceptability scores for T1 (12 %), T2 (18 %) and T3 (24 %) *laddo* was 8.41, 8.18 and 8.12, respectively (Table 2).

3.4 Groundnut meal *laddo*: Three types of groundnut meal based *laddo* were prepared. Mean acceptability scores for color, appearance, aroma, texture, taste, and overall acceptability of T1 *laddo* were 8.38, 8.30, 8.68, 7.98, 8.14, and 8.30, respectively. Mean acceptability scores for color, appearance, aroma, texture, taste, and overall acceptability of T2 *laddo* were 8.36, 8.10, 8.17, 7.91, 7.91, and 8.09, respectively. Mean acceptability scores for color, appearance, aroma, texture, taste, and overall acceptability of T3 *laddo* were 8.31, 8.10, 8.11, 7.88, 7.90, and 8.06, respectively (Table 2).

Table 2: Organoleptic acceptability of *laddo* incorporating sesame, flaxseed, groundnut, and composite meal (Mean scores)

Types of *laddo*		Color	Appearance	Aroma	Texture	Taste	Overall acceptability
Control	**Control**	8.87±0.06	8.70±0.09	8.70±0.09	8.50±0.08	8.63±0.06	8.68±0.14
Sesame meal	**T1**	8.38±0.09	8.40±0.1	8.26±0.15	8.00±0.01	8.30±0.15	8.27±0.1
	T2	8.38±0.19	8.30±0.13	8.16±0.21	7.98±0.05	8.24±0.21	8.21±0.09
	T3	8.33±0.07	8.10±0.17	8.09±0.16	7.91±0.07	8.18±0.06	8.12±0.12
Flaxseed meal	**T1**	8.48±0.11	8.60±0.15	8.40±0.23	8.04±0.06	8.23±0.11	8.41±0.11
	T2	8.40±0.13	8.20±0.08	8.19±0.19	7.92±0.08	8.21±0.15	8.18±0.06
	T3	8.34±0.13	8.20±0.2	8.12±0.15	7.88±0.08	8.04±0.13	8.12±0.05
Groundnut meal	**T1**	8.38±0.07	8.30±0.1	8.68±0.1	7.98±0.01	8.14±0.02	8.30±0.16
	T2	8.36±0.03	8.10±0.12	8.17±0.04	7.91±0.06	7.91±0.02	8.09±0.05
	T3	8.31±0.16	8.10±0.03	8.11±0.03	7.88±0.03	7.90±0.07	8.06±0.09
Composite meal	**C1**	8.39±0.11	8.80±0.13	8.70±0.15	8.42±0.05	8.80±0.12	8.62±0.19
	C2	8.34±0.13	8.80±0.15	8.60±0.06	8.27±0.07	8.66±0.02	8.53±0.2
	C3	8.30±0.1	8.70±0.15	8.45±0.06	8.00±0.1	8.41±0.04	8.37±0.19
C.D.≤0.05		N/A	0.37	0.41	0.18	0.31	N/A

Values are mean of ten panelists

Control- without any oilseed meal incorporation (T1, T2 and T3 are 12%, 18%, and 24%).

3.5 Composite meal *laddo*: All the three oilseed meals mixed in equal proportion and used as composite meal which was incorporated at 12, 18 and 24 % level in *laddo*. Result delineates that mean acceptability scores for C1 (12 %) *laddo* were 8.39, 8.80, 8.70, 8.42, 8.80, and 8.62 for color, appearance, aroma, texture, taste, and overall acceptability, respectively. Mean

acceptability scores for color, appearance, aroma, texture, taste, and overall acceptability of C2 (18 %) *laddo* were 8.34, 8.80, 8.60, 8.27, 8.66, and 8.53, respectively. Mean acceptability scores for C3 (24 %) *laddo* were 8.30, 8.70, 8.45, 8.00, 8.41, and 8.37 for color, appearance, aroma, texture, taste, and overall acceptability, respectively whereas mean acceptability scores of control *laddo* were 8.87, 8.70, 8.70, 8.50, 8.63, and 8.68 for color, appearance, aroma, texture, taste, and overall acceptability, respectively (Table 2).

All types of supplemented *laddo* were organoleptically acceptable and overall acceptability of each *laddo* lied in 'liked very much' so, the highest level of incorporation level were selected and studied for nutritional analysis.

3.6 Nutritional evaluation- The moisture content of all *laddo's* lied between 0.05 to 0.96 %. The crude protein was observed to be 20.03 % in groundnut meal *laddo,* 18.34 % in composite meal *laddo*, 16.58 % in sesame meal *laddo*, 13.35 % in flaxseed meal *laddo* and 9.16 % in control *laddo*. However, control *laddo* fat content was 23.54 % which was significantly ($P \leq 0.05$) low. The values of ash content of oilseed incorporated *laddo* varied between 2.44 % to 5.70 %. The amount of crude fiber was found 4.28 % in flaxseed meal *laddo,* 4.19 % in groundnut meal *laddo* and 2.65 % in control *laddo* whereas in composite meal *laddo* crude fiber content was 5.14 % and in sesame meal *laddo* crude fiber content was 4.85 %. Significantly ($P \leq 0.05$) low values were observed for crude protein, crude fat, ash and crude fiber of control laddo as compared to oilseed meal based *laddo* (Table 3).

Table 3: Proximate composition of oilseed meal based *laddo* (%, on dry matter basis)

Types of *Laddo*	Moisture	Crude Protein	Crude Fat	Ash	Crude Fiber
Control	0.96±0	9.16±0.09	23.54±0.31	2.44±0.01	2.65±0
Sesame meal	0.14±0	16.58±0.38	27.8±0.52	5.7±0.02	4.85±0
Flaxseed meal	0.05±0	13.35±0.02	35.99±0.65	3.97±0.01	4.28±0.08

Groundnut meal	0.41±0	20.03±0.45	25.52±0.07	4.66±0.06	4.19±0.04
Composite meal	0.08±0	18.34±0.27	30.6±0.43	4.19±0.02	5.14±0.07
C.D.(P≤0.05)	0.01	0.94	1.42	0.1	0.17

Values are mean±SE of three independent determinations

* Moisture calculated on wet matter basis.

* SE=Standard error.

Comparison of protein and moisture of all the selected oilseed meal *laddo* indicated that it was significantly (P≤0.05) high in groundnut meal. Sesame and flaxseed had almost similar protein. Comparison of fat content of all the oilseed meal *laddo* indicated that crude fat content of flaxseed meal *laddo* was significantly high (35.99%) as compared to sesame meal, groundnut meal and composite meal *laddo*. High fat content in flaxseed meal *laddo* was due to fact that oil from flaxseed was extracted with cold pressed method in which the oil retention is more in meal. Control *laddo* had lowest fat i.e. 23.45%. Significant (P≤0.05) difference observed in fat content among all oil seed meal *laddo* may be due to fat content of oil seed and method of oil extraction used. The comparison of ash content among sesame, flaxseed, groundnut and composite meal *laddo* revealed that ash content was significantly(P≤0.05) high in sesame meal *laddo* and lowest in control *laddo*. A variation was observed in crude fiber content among all oil seed meal *laddo* evaluated. Maximum amount of crude fiber was found in composite meal *laddo* and lowest found in control *laddo* whereas flaxseed meal and groundnut meal *laddo* had almost similar amount of crude fiber.

The experiment was planned due to lack of literature available for traditional food products based on oilseed meals and the results obtained for organoleptic acceptability were highly acceptable. However, there was no data available for the developed products from oilseed meal, although data on the proximate composition of oilseed meals were available (Table 4).

TABLE 4: Nutritional composition of sesame meal (Per cent)

Sesame meal					
Sr. no.	**Protein**	**Fat**	**Fibre**	**Ash**	**Reference**
1.	35.16	5.52	23.52	9.98	Hira *et al.* (2002)
2.	41.04	8.05	6.1	11.13	Nadeem *et al.* (2005)
3.	44.42	13.11	8.75	14.15	Babiker (2012)
4.	51.55	6.24	9.59	11.34	Son *et al.* (2017)
5.	44.9	11.3	7.3	11.9	Heuze *et al.* (2017)
Flaxseed meal					
1.	41.12	5.63	8.76	5.38	Bell *et al.* (1993)
2.	32.9	9.1	13.2	6.6	De Boever *et al.* (1994)
3.	34.56	6.3	10.01	6.5	Masoero *et al.* (1994)
4.	38.00-47.30	12.8-26.1	-	3.7-5.1	Ogunronbi *et al.* (2011)
5.	38.4	12.8	7.2	5.1	Kyntaja *et al.* (2014)
6.	34.1	10.2	10.5	6.3	Heuze *et al.* (2017)
Groundnut meal					
1.	45.1	9.9	4	7.9	Awoniyi *et al.* (2003)
2.	38.59	8.55	7.52	6.13	Chandrasekharaiah *et al.* (2004)
3.	52.45	10.56	4.8	5.5	Adewolu *et al.* (2010)
4.	42.87	7.75	--	5.51	Gupta *et al.* (2011)
5.	53.44	7.47	8.55	5.27	Babiker (2012)
6.	49.1	9.8	7	5.8	Heuze *et al.* (2018)

* The mean values of proximate composition of sesame meal, flaxseed meal, and groundnut meal obtained by mechanical extraction as reported by various researchers in different studies

4. Conclusion

One serving (25gm) of *laddo* can meet the 27% requirement of protein for pre-schoolers as per RDA (recommended dietary allowance). It can be summarized from the present study that the *laddo* made using oilseed meals is nutrient-dense which contains protein, fat, ash, crude fiber

content in ample amounts. The study has shown a potential use of inexpensive and underutilized oilseed meals in the preparation of various food products for human consumption. The developed value-added *laddo* could be efficiently used as a means of improving the nutritional status of the community by popularizing and making them reach the masses to overcome malnutrition. The *laddo* if promoted will also help in the utilization of oilseed meals which are generally discarded. Sesame meal, flaxseed meal, groundnut meal and composite meal of different meals can be used to supplement foods consumed as a part of daily diet.

Disclaimer (Artificial intelligence):

The Author(s) hereby declares that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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