

Quality Evaluation of Buckwheat Flour Incorporated Sesame Laddu and its Popularization

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Abstract

The perception of food and nutrition security is multi-dimensional. Food security happens when all individuals have physical and economic access to enough and nutritious food which meets their dietary requirements and food choice for an active and healthy life. Limited quantity and supply of nutritious food is a big threat for food security. Because of huge population and high level of malnutrition in India, it is a very big challenge to make sure the supply of sufficient food and nutrition. Buckwheat has become a functional food because of its nutrient content and positive effects on human health. It can be consumed as a food and also used in the treatment of many diseases. The major impacts of buckwheat on human health are its hypotensive, hypoglycemic, hypocholesterolemic, neuroprotective and antioxidant effects. Hence, it is used in the treatment for chronic and metabolic diseases, such as diabetes, hypertension and celiac disease. Buckwheat flour was incorporated in sesame laddu at four different proportions (10%, 20%, 30% and 40%) and the formulated samples along with the standard were standardized. After standardization, it was subjected to sensory analysis and most acceptable proportion was selected and subjected for nutrient analysis. The cost of the product was also estimated. The selected product was popularized among adults. The sensory analysis proved that the sensory characteristics are acceptable with the addition of buck wheat flour. The carbohydrate content was high and the fat content was low in the selected product than in the standard product. The selected product costs little higher than the standard product.

Key Words: Buckwheat flour, sesame, laddu, sensory analysis, nutrient analysis

1. Introduction

Food security depends on the food production to prevent scarcity, increasing food availability and access to food at reasonable price, to meet the nutritional requirements and preventing malnutrition in the rising population [1]. Many people are not having access to inexpensive, healthy and safe foods throughout the year to achieve proper health and wellbeing. By means, malnutrition is a global problem in all forms and none of the country is excused from its ill effects. Every one person in three is now affected by any one type of under-nutrition like stunting, wasting, hidden hunger (micronutrient deficiency) or over-nutrition such as overweight, obesity and in addition with non-communicable diseases [2, 3].

Buckwheat is a main constituent in many food products and it is grown for its starch content for more than 4,000 years. Along with the high starch content, it is also a gluten free food ingredient. It has an excellent nutritive value, good quality protein and high amount of fiber, vitamins and minerals. The flavonoid rutin which is present in buckwheat has significant antioxidant property. Hence buckwheat is considered as a therapeutic food which is grown all over the world. Buckwheat is a favorable pseudo cereal. Because of its high nutritive value and medicinal properties, buckwheat is considered not only as a regular crop but can also be a sign of healthy life [4, 5].

Functional foods are defined as the one which protect from diseases, improves health and reduce the risk of disease. Thus, the consumption and availability of functional food is increased [6, 7]. Buckwheat has numerous helpful properties on health due to its high nutritional value. It is understood that buckwheat could prevent the origin of many diseases like diabetes mellitus, atherosclerosis, hypercholesterolemia and hypertension. Rutin, a flavonoid present in higher amount in buckwheat, is used in the medical field in various countries to decrease or prevent capillary deformations which arise as an outcome of hypertension and hemorrhagic diseases [8-11].

Buckwheat has a high biological value protein which has well-proportioned amino acid content. Buckwheat also comprises of biologically active components like phenolic acid, flavonoids and phytosterols. These components have an antioxidant property [12, 13]. Phytonutrients present in the buckwheat are effective substances which are helpful in reducing the blood cholesterol and blood pressure [14].

Diabetes mellitus is a chronic metabolic disease connected with insufficient secretion of insulin or a rise in blood glucose level which is resulted due to inefficient activity of insulin. To manage and treat diabetes mellitus, intake of foods containing carbohydrate based on its Glycemic Index (GI) was found to be helpful [15-17]. The resistant starch present in buckwheat has a low GI. Low GI foods can control blood glucose level, diminish the risk of heart diseases and also helps in preventing obesity. Hence, buckwheat is helpful in the management of metabolic diseases [8, 18, 19].

When compared to legumes and wheat, buckwheat contains the anti-nutritional components like polyphenols and enzyme inhibitors which delay the digestion process. This interruption in the digestion favours the control of plasma glucose level. Consumption of buckwheat along with a well-balanced diet had a positive effect on insulin production and to control the blood lipid level [21]. Even though it is essential for people with diabetes mellitus to adhere to the diet counselling to improve the health and to prevent complications, access to sufficient and superior quality food is difficult for people existing in a household which is lacking with food security [22].

By keeping the above points in consideration, the present study was planned to prepare a ready to eat snack and the objectives are as follows:

- ❖ To formulate and standardize buckwheat flour incorporated sesame laddu.
- ❖ To evaluate the sensory and nutritional quality of standard and buckwheat flour incorporated sesame laddu
- ❖ To study the shelf life of standard and selected buckwheat flour incorporated sesame laddu
- ❖ To estimate the cost of standard and selected buckwheat flour incorporated sesame laddu
- ❖ To popularize buckwheat flour incorporated sesameladdu

2. Materials and Methods

2.1. Section of Product

Laddu is a circle shape sweet made commonly in Southern Asia. Laddus are generally prepared with flour, fat, sugar and other ingredients [22]. Now a days, the individuals are getting busy with their day to day work. Thus, formulating a new product is essential for a rising economy. The less time available for food preparation makes the people to eat unwholesome and treated/processed food. Hence, formulation of a healthy nutrient rich ready to eat snack is getting more attention by the food industry and also among the community. In the present study, buckwheat flour, an ingredient with numerous health benefits was incorporated with sesame seed to prepare laddu.

2.2. Formulation and Standardization

The major ingredients for sesame laddu are sesame seed and jaggery. In the present study, buckwheat flour was incorporated in sesame laddu at a proportion of 10%, 20%, 30% and 40% in samples A, B, C and D respectively. Standard product along with four variations was formulated and after standardization, they were kept for sensory analysis.

Standardization is the method of increasing and executing technical standards. The formulated products were standardized by developing the samples many times with the measured quantity raw materials using a standard preparation method. The standardized products are given in Plate – 1.



Plate – 1 – Standard and Buckwheat Flour Incorporated Sesame laddu

2.3. Sensory Analysis

The standardized products were evaluated for its sensory characteristics using a score card with five point scale which includes appearance, color, flavor, texture and taste. The products were set according to the variations. Sensory analysis was performed by thirty semi trained panel members who are associated to nutrition field. The scores given by the panel members in sensory evaluation were consolidated and the most acceptable product was selected by means of highest mean score using statistical analysis. Plate -2 shows the conduct of Sensory analysis.



Plate 2 - Conduct of Sensory Analysis

2.4. Nutrient Analysis

Nutrient analysis refers to the process of determining the nutritional content of foods and food product. Buckwheat contains high carbohydrate with low to moderate GI and low fat content which are favourable for people with diabetes mellitus and cardiovascular diseases. It also contains high quality protein with balanced amino acid composition. Hence, the standard and selected proportion of buckwheat flour incorporated sesame laddu was analyzed for its carbohydrate, protein, fat, fibre, iron and calcium content by AOAC (2005) methods. Energy content of the products was calculated by factorial method using the analyzed value of carbohydrate, protein and fat.

2.5. Shelf-life Study

Microbial analysis is nearly an essential aspect to ensure the food safety. The chance of contamination of foods under regular usage conditions is tested to prevent food processing outburst. Experiments like checking the presence of harmful pathogens and organisms are mandatory. Hence, the microbial analysis was done for three weeks at periodic intervals to assess the storage stability of the product by pour plate technique [24]. Sensory analysis of the nutritious laddu for storage study was done every week using composite scoring test by twelve semi trained panel members. The criteria includes were sweetness, texture, taste and over all acceptability. The taste and texture were evaluated out of 25 marks, sweetness and overall acceptability were evaluated for 20 marks and 30 marks respectively. Bulk preparation of the samples were done and used in the sensory analysis for three weeks [25]. The shelf-life study of standard and selected proportion of buckwheat flour incorporated sesame laddu was done for 9 days by microbial analysis (TBC) on the 1st day, 4th day and 8th day and sensory analysis on the 1st day, 5th day and 9th day. The products were packed in the zip lock cover at room temperature to analyze its storage stability.

2.6. Cost Analysis

Budgeting/costing is a vital part in product formulation. The formulated product must be cost effective to make it available for people from all income groups. The ingredients for bulk preparation were purchased in the wholesale shop to reduce the price [25]. The cost estimation of standard and selected buckwheat flour incorporated sesame laddu was done based on the quantity of ingredients used in product formulation and its price in local market. Labour cost and fuel cost were also included in cost estimation. Cost analysis is helpful to check the economic feasibility of the formulated product.

2.7. Popularization

Popularization is the process of making the product attractive to the people in the community. The selected proportion of buckwheat flour incorporated sesame laddu was popularized among 30 adult women. The awareness about the health and nutritional benefit of buckwheat was taught to them during the popularization process. A score card with 3 point scale was prepared and given to the participants of popularization study to evaluate the sensory attributes of buckwheat flour incorporated sesame laddu.

2.8. Statistical Analysis

The scores given by the thirty panel members during the sensory analysis were analyzed using the statistical tools mean and standard deviation to find the most acceptable proportion.

3. Results

The results depict the major outcomes of the study. The major findings of the present study are given below.

3.1. Sensory Analysis

The standard and formulated products were analyzed by thirty semi trained panelist and the scores were consolidated and analyzed using mean and standard deviation (Table 1). The best proportion was selected based on the highest mean score.

Table 1
Mean Score for Sensory Analysis (n=30)

Products	Maximum Score	Mean Score $\pm$ Standard Deviation				
		Appearance	Colour	Flavour	Texture	Taste
Standard	5	4.9 $\pm$ 0.30	4.87 $\pm$ 0.50	4.83 $\pm$ 0.46	4.9 $\pm$ 0.40	4.9 $\pm$ 0.30
Sample A	5	4.86 $\pm$ 0.34	4.77 $\pm$ 0.43	4.63 $\pm$ 0.55	4.73 $\pm$ 0.44	4.57 $\pm$ 0.89
Sample B	5	4.83 $\pm$ 0.46	4.87 $\pm$ 0.34	4.67 $\pm$ 0.54	4.86 $\pm$ 0.34	4.63 $\pm$ 0.76
Sample C	5	4.63 $\pm$ 0.66	4.57 $\pm$ 0.72	4.06 $\pm$ 1.08	4.6 $\pm$ 0.67	4.16 $\pm$ 1.11
Sample D	5	4.80 $\pm$ 0.48	3.87 $\pm$ 1.38	3.7 $\pm$ 1.23	4.1 $\pm$ 1.12	3.8 $\pm$ 1.29

From the above table it is clear that, standard sesame laddu got the highest mean score for all the five criterias. Among the samples, sample A got the highest mean score for appearance. For the criterias colour, flavour, texture and taste sample B got the highest mean score. While considering the overall mean score, sample B got the highest score among the samples and selected as best proportion for further studies.

3.2. Nutrient Analysis

Nutrients such as carbohydrate and fat content of the standard and selected buckwheat flour incorporated laddu were analyzed using standard procedures and the results are given below.

Table 2
Nutrient Analysis of Standard and Selected Product

S.No	Nutrient (per 100g)	Standard Product	Selected Product
1	Energy (Kcals)	514.52	482.4
2	Carbohydrate (g)	45.30	51.15
3	Protein (g)	12.32	11.58
4	Fat (g)	31.56	25.72
5	Fibre (g)	11.38	10.62
6	Calcium (mg)	128.52	117.56
7	Iron (mg)	6.57	6.04

The above table depicts that, the carbohydrate content of standard product was 45.30g and selected product was 51.15g. The protein and fat content of standard product were 12.32g and 31.56g respectively whereas selected product contains the protein content of 11.58g and fat content of 25.72g. The energy content of standard product and selected product were

514.52kcal and 482.4kcal respectively. The fibre content of standard product was 11.38g whereas in standard product it was 10.62g. The calcium and iron content of selected product were 117.56mg and 6.04mg respectively. In standard product, the calcium content was 128.52mg and iron content was 6.57mg.

3.3. Shelf-life Study

Shelf-life study of standard and selected buckwheat incorporated sesame laddu was done by microbial analysis and sensory analysis after packing the products in zip lock cover.

3.3.1. Microbial Analysis

Microbial analysis of standard and buckwheat flour incorporated sesame laddu was done on the 1st day, 4th day and 8th day after packing in zip lock cover and the results are given below.

Table 3
Microbial Analysis of Standard Product and Selected Product

Days	Name of the Product	Indicator Test Result (CFU / gram) and Interpretation/Standard Plate Count			
		G	M/S	US	P H
Day 1	Standard	✓	-	-	-
	Selected product	✓	-	-	-
Day 4	Standard	✓	-	-	-
	Selected product	✓	-	-	-
Day 8	Standard	✓	-	-	-
	Selected product	✓	-	-	-
Organism identified	For standard product at the end of 8th day 9^{104} cfu/g bacterial growth was absorbed. For selected product 4th day 6^{104} cfu/g and 8th day $1.4^{104} \times 10^1$ cfu/g bacterial growths was observed.				

(Good= G; Satisfactory = S; Marginal = M; Unsatisfactory = US; Potentially Hazardous=PH)

Microbial analysis was done for standard and selected products packed in zip lock cover on 1st, 4th and 8th day. The above table reveals that, in standard product there was no microbial growth on the 1st and 4th day, but a slight bacterial growth was absorbed on the 8th day. In the selected product, there was no microbial growth on the 1st day of analysis, but on the 4th day and 8th day a slight bacterial growth was observed which was within the permissible limit.

3.3.2. Sensory Analysis

Buckwheat flour incorporated sesame laddu had a good shelf life of up to 9 days under room temperature by the use of zip lock cover packaging. The mean score for sensory analysis of standard and buckwheat flour incorporated selected product revealed that, On the 1st day the mean score for appearance were 4.96 ± 0.18 and 4.93 ± 0.25 , colour were 4.96 ± 0.18 and 4.9 ± 0.30 , texture were 4.83 ± 0.46 and 4.86 ± 0.34 , flavour were 4.76 ± 0.50 and 4.63 ± 0.55 , taste were 4.86 ± 0.34 and 4.83 ± 0.37 respectively for standard and selected product.

The mean scores of standard product on the 5th day were 4.9 ± 0.30 , 4.9 ± 0.30 , 4.53 ± 0.81 , 4.36 ± 0.88 and 4.4 ± 0.96 and the mean scores of buckwheat flour incorporated sesame laddu were 4.9 ± 0.30 , 4.86 ± 0.34 , 4.8 ± 0.40 , 4.33 ± 0.99 and 4.36 ± 0.76 respectively for the criterias appearance, colour, flavour, texture and taste. On the 9th day of analysis, the mean scores of appearance were 4.86 ± 0.34 and 4.83 ± 0.37 , colour were 4.83 ± 0.46 and 4.8 ± 0.40 , texture were 4.53 ± 0.81 and 4.46 ± 1.07 , flavour were 4.13 ± 1.30 and 3.9 ± 1.27 , taste were 4.16 ± 1.08 and 4.06 ± 1.36 respectively for standard and buckwheat flour incorporated sesame laddu. There was a slight change in the mean scores on the 1st day till the 9th day of sensory analysis.

3.3.3. Cost Estimation

Cost estimation is the key part of promotion and customer acceptance. Cost of the standard and selected buckwheat flour incorporated sesame laddu was done by calculating the current market price of the ingredients used in the preparation such as sesame seeds, jaggery and buckwheat flour. It was found that, 100g of standard sesame laddu costs Rs.22.40 and the cost of 100g of buckwheat flour incorporated product was Rs. 30.2. The cost difference between the standard and buckwheat flour incorporated sesame laddu was Rs.7.80 which is due to the addition of buckwheat. However the extra cost is worth paid for the nutritional and health benefits provided by buckwheat.

3.3.4. Popularization

The prime aim of the popularization programme was to create awareness among the public about the beneficial effects of buckwheat flour incorporated sesame laddu and their contribution to health. Popularization of buckwheat flour incorporated sesame laddu was done among thirty adult women by briefing on its significance, functional properties, nutritional aspects and benefits. The below table shows the sensory score given by 30 participants involved in the popularization study.

Table 4
Mean Sensory Score of Buckwheat Flour Incorporated Laddu
during Popularization

(n=30)

S.No	Criteria	Max Score	Mean $\pm$ SD
1	Appearance	3	2.83 ± 0.37
2	Colour	3	2.96 ± 0.18
3	Texture	3	2.96 ± 0.18
4	Flavour	3	2.9 ± 0.30
5	Taste	3	2.86 ± 0.34

From the above table it is noted that, the mean scores for appearance, colour, texture, flavour and taste of buckwheat flour incorporated sesame laddu were 2.83 ± 0.37 , 2.96 ± 0.18 , 2.96 ± 0.18 , 2.9 ± 0.30 and 2.86 ± 0.34 respectively. Thus it is clear that the participants of popularization liked the buckwheat flour incorporated laddu.

4. Discussion

Nigar et al., (2017) developed a laddu using pumpkin seed and walnut flour incorporated with buckwheat. Three samples were prepared with the addition of buckwheat at 40%, 30% and 20% and sensory analysis was performed using a score card with nine-point hedonic scale by the panel members. The result indicated that, laddu with 30% buckwheat was

selected as most acceptable product [26]. In the present study, buckwheat flour was incorporated at 10%, 20%, 30% and 40% level. Sample B with 20% buckwheat flour i.e 13g buckwheat flour was selected as a best product by the panel of judges.

The amount of carbohydrate in the buckwheat flour incorporated sesame laddu was higher than standard sesame laddu and the fat content was less in buckwheat flour incorporated sesame laddu when compared to the standard product. The high carbohydrate with low Glycemic Index and low fat content in the buckwheat flour incorporated sesame laddu has a positive benefit for people with diabetes and hypercholesterolemia. The study done by Farzana et al., (2021) revealed that, the carbohydrate content was lower in cake made with the addition of buckwheat flour than the standard cake made only with wheat flour. The protein content was between 11.9 and 15.3%, the fibre content was ranged from 0.3 to 0.4% and the fat content was ranged from 36.4 to 41.2% in the buckwheat flour incorporated cake. There was a significant increase in the amount of nutrients like protein, fibre, fat, ash, iron and calcium at 5% level [27].

The result of microbial analysis of buckwheat flour incorporated sesame laddu showed that till the 8th day of microbial analysis no contamination and harmful organisms were found in both standard and selected products. The findings are comparable to the reports of Anuradha et al. [24]. Microbial analysis was conducted for calpro laddu using pour plate method. The results were tested by Total Plant Count (TPC). The number of colonies found in the test was within the permissible level. The result revealed that the formulated laddu had a good shelf life. In another study, microbial analysis was performed to find the storage stability of multi grain laddu. Pour plate technique was used and the number of colonies developed were identified. The result showed that the microbial growth was within the acceptable level and the laddu was safe and harmless for human consumption [22].

Nutritious laddu was prepared and sensory analysis for storage study was done for 3 weeks. The results revealed that, the mean score for both taste and texture were marginally decreased from 22 on the 1st week to 20 on the 2nd and 3rd week. The score for sweetness was 20 on the 1st week, 18 on the 2nd week and 17 on the 3rd week. The score for overall acceptability was also slightly decreased from 26 (1st week) to 22 on the 3rd week [25]. Similar results were found in the present study. The mean score for sensory analysis during shelf life study of standard sesame laddu and buckwheat flour incorporated laddu showed that, the sensory scores for the criterias appearance, colour, flavour, texture and taste were in the decreasing order while comparing the 1st day, 5th day and 9th day.

Laddu formulated for lactating women using the ingredients jaggery, ghee, cornflakes, oats, nuts, milk powder, etc. and it costs Rs. 26 for 40g laddu [28]. In another study, Calpro laddu was prepared using ragi as a main ingredient. The cost analysis revealed that 60g of calpro laddu costs Rs.20 [24]. Comparable result was noted in the present study in which, cost of 100g of buckwheat flour incorporated sesame laddu was Rs.30.2.

Mahua laddu was popularized among the farmers by kisan mela, leaflets and handouts. The participants showed a positive response [29]. However in the present study, the buckwheat flour incorporated sesame laddu was popularized by conducting sensory analysis among adult women and the mean score of sensory analysis showed that, the product was liked by all the participants. This proves that, popularization is a preferable choice for promoting new products in the community.

5. Conclusion

Buckwheat flour incorporated in sesame laddu doesn't affect the sensory attributes. Addition of buckwheat flour increased the carbohydrate and decreased the fat content in the selected laddu. It was also noted that the formulated laddu was microbiologically safe for human consumption upto 9 days without much changes in the sensory characteristics. The cost of the product is acceptable while considering the nutritional and health benefits of buckwheat.

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Conflict of Interest

All authors declare that they have no conflicts of interest.

References

- [1]. Prema Ramachandran. (2013) Food & nutrition security: Challenges in the new millennium Indian J Med Res. 138(3): 373–382
- [2]. FAO & WHO. (2015) Second International Conference on Nutrition (ICN2). Report of the Joint FAO/WHO Secretariat on the Conference. <http://www.fao.org/3/i4436e/i4436E.pdf>
- [3]. Global Panel. 2016. The Cost of Malnutrition: Why Policy Action is Urgent. London, UK: Global Panel on Agriculture and Food Systems for Nutrition. <https://glopan.org/sites/default/files/pictures/CostOfMalnutrition.pdf>
- [4]. Ryo Ohsawa, Katsuhiko Matsui, and Yasuo Yasui. (2020) Current research and future prospects in common buckwheat (*Fagopyrum esculentum*), Breed Sci. 70(1): 1.
- [5]. Wen, W.; Li, Z.; Shao, J.; Tang, Y.; Zhao, Z.; Yang, J.; Ding, M.; Zhu, X.; Zhou, M. (2021) The Distribution and Sustainable Utilization of Buckwheat Resources under Climate Change in China. Plants, 10, 2081. <https://doi.org/10.3390/plants10102081>
- [6]. Wronkowska M, Soral-Smietana M, Krupa-Kozak U. (2010) Buckwheat, as food component of a high nutritional value, used in the prophylaxis of gastrointestinal diseases. Eur J Plant Sci Biotechnol. 4: 1-7.
- [7]. Sun T, Ho CT. (2005) Antioxidant activities of buckwheat extracts. Food Chem. 90: 743-9. <http://dx.doi.org/10.1016/j.foodchem.2004.04.035>
- [8]. Zhang ZL, Zhou ML, Tang Y, et al. (2012) Bioactive compounds in functional buckwheat food. Food Res Int. 49: 389-95. <http://dx.doi.org/10.1016/j.foodres.2012.07.035>
- [9]. Brajdes C, Vizireanu C. (2012) Sprouted buckwheat: an important vegetable source of antioxidants. Food Technol. 36: 53-60.
- [10]. Bao T, Wang Y, Li YT, et al. (2016) Antioxidant and antidiabetic properties of tartary buckwheat rice flavonoids after in vitro digestion. J Zhejiang Univ Sci B. 17(12): 941-51. <http://dx.doi.org/10.1631/jzus.B1600243> PMID: 27921399
- [11]. Zhang C, Zhang R, Li YM, et al. (2017) Cholesterol-lowering activity of tartary buckwheat protein. J Agric Food Chem. 65(9): 1900-6. <http://dx.doi.org/10.1021/acs.jafc.7b00066> PMID: 28199789
- [12]. Kato, N., Kayashita, J., Tomotake, H. (2001) Nutritional and physiological functions of buckwheat protein. Recent Research Development Nutrition. 4: 113–119.
- [13]. Bojnanska, T., Francakova, H., Chlebo, P., Vollmannova, A. (2009) Rutin content in buckwheat enriched bread and influence of its consumption on plasma total antioxidant status. Czech Journal of Food Sciences. 27(SPEC.ISS.).
- [14]. Bikram Nepali, Devashish Bhandari, Jiban Shrestha (2019). Mineral Nutrient Content of Buckwheat (*Fagopyrum esculentum* Moench) for Nutritional Security in Nepal. Malaysian Journal of Sustainable Agriculture. 3(1): 01-04.

- [15]. Ortiz LG, Berry DC, Ruiz OC, González ER, Pérez PA, Rivas EdelÁ. (2014) Understanding basic carbohydrate counting, glycemic index, and glycemic load for improved glycemic control in Hispanic patients with type 2 diabetes mellitus. *Hisp Health Care Int.* 12(3): 138-45. <http://dx.doi.org/10.1891/1540-4153.12.3.138> PMID: 25239210
- [16]. Zhu F. Buckwheat starch: Structures, properties, and applications. (2016) *Trends Food Sci Technol.* 49: 121-35. <http://dx.doi.org/10.1016/j.tifs.2015.12.002>
- [17]. Wang ML, Gellar L, Nathanson BH, et al. (2015) Decrease in glycemic index associated with improved glycemic control among latinos with type 2 diabetes. *J Acad Nutr Diet.* 115(6): 898-906. <http://dx.doi.org/10.1016/j.jand.2014.10.012> PMID: 25547339
- [18]. Kreft I, Skrabanja V. (2002) Nutritional properties of starch in buckwheat noodles. *J Nutr Sci Vitaminol (Tokyo)* 48(1): 47-50. <http://dx.doi.org/10.3177/jnsv.48.47> PMID: 12026188
- [19]. Bonafaccia G, Fabjan N. (2003) Nutritional comparison of tartary buckwheat with common buckwheat and minor cereals. *Zb Bioteh Fak Univ Ljubl Kmet.* 81: 349-55
- [20]. Qiu J, Liu Y, Yue Y, Qin Y, Li Z. (2016) Dietary tartary buckwheat intake attenuates insulin resistance and improves lipid profiles in patients with type 2 diabetes: a randomized controlled trial. *Nutr Res.* 36(12): 1392-401. <http://dx.doi.org/10.1016/j.nutres.2016.11.007> PMID: 27919453
- [21]. Tezera R, Sahile Z, Yilma D, Misganaw E, Amare E, Haidar J. (2022) Food security status of patients with type 2 diabetes and their adherence to dietary counselling from selected hospitals in Addis Ababa, Ethiopia: A cross-sectional study. *PLoS ONE* 17(4): e0265523. <https://doi.org/10.1371/journal.pone.0265523>
- [22]. Bhargavi .G. Naidu, Kirti .J. Shirke and Anuradha Shekhar. (2013) A Study of a Galactogouge and Protein Rich – Multigrain Ladoo. 2(2): 91-94. e-ISSN: 2320-7876
- [23]. AOAC. (2005) Official methods of analysis of association of official analytical chemistry International, 18th Ed. Association of Analytical Communities, Gaithersburg, Maryland, USA.
- [24]. Anuradha Shekhar, et al. (2019) Shelf Life Study and Acceptability of Calpro Ladoo. *Acta Scientific Nutritional Health.* 3(4): 10-13.
- [25]. Savla Rutu, Savla Pearl and Anuradha Shekhar. (2017) A Shelf Life Study of Nutritious Ladoo. *International Journal of Food and Nutritional Sciences.* 6 (3): 57-60. e-ISSN 2320 -7876 www.ijfans.com
- [26]. Nigar Naqvi, Luxita Sharma, Mohsin Ali Khan. (2017) Development & standardization of buckwheat laddu with added walnut & pumpkin seed flour & their sensory attributes. *International Journal of Food Science and Nutrition.* 2(6): 115-118.
- [27]. Farzana T, Fatema J, Hossain F.B, Afrin S, Rahman S.S. (2021) Quality Improvement of Cakes Buckwheat Flour, and its Comparison with Local Branded Cakes. *Curr Res Nutr Food Sci.* 9(2): 570-577. <https://dx.doi.org/10.12944/CRNFSJ.9.2.20>.
- [28]. Sakina Mamka, Ruchi Jain, Anuradha Shekhar. (2020) Development of an innovative laddu for lactating women and its shelflife study, *International Journal of Creative Research Thoughts (IJCRT).* 8(5): 2840-2852.
- [29]. Yuvarani S and Anitha V. (2016) A Study on the consumer acceptance, Nutritive value and Antioxidant activity of Multigrain Ladoo. *International Journal of Home Science.* 2(3): 227-232.