

NUTRITIONAL, SENSORY, AND GLYCEMIC EVALUATION OF OAT AND BAELE-ENRICHED PASTA

¹Mohammed Alhassan Fuseini and ²Akosua Adjei Serwaa

Faculty of Home science (Food Science and Nutrition), Banasthali Vidyapith, Jaipur,
Rajasthan, India

DOI: <https://doi.org/10.5281/zenodo.17513313>

Abstract

Cereal grains and fruits are essential components of the daily diet due to their nutritional content and therapeutic potential. These functional ingredients are rich in soluble fibers and phytochemicals, which may help reduce the risk of obesity, diabetes, cardiovascular disease, and cancer. This study evaluated oat (Avena sativa) and bael (Aegle marmelos) incorporated pasta for its sensory properties using a 9-point hedonic scale, proximate composition, quantitative phytochemical analysis, nutrient profiling, lipid profile, and glycemic index (GI) using standard methods. Results demonstrated that the pasta was rich in fiber, protein, soluble starch, amylose, resistant starch, omega-6 fatty acids, total phenols, and phytic acid. The findings suggest that incorporating such functional ingredients enhances the nutritional and medicinal properties of food products, offering potential health benefits. The study highlights the importance of these ingredients for food formulation, emphasizing their pharmacological and therapeutic applications. These results support the inclusion of functional ingredients like oat and bael in diet-based interventions to promote health and prevent metabolic disorders.

Keywords: *Avena sativa, Aegle marmelos, Functional foods, Diabetes, Glycemic index*

Introduction

In the ancient times, diabetes mellitus referred to as first identifiable disease associates with sweet urine and muscle loss. In the world, diabetes is third most common disease with “cardiovascular and oncological” disorders. India has declared as “Diabetic capital” according to World Health Organisation (Bordoloi and Dutta, 2014) [1].

Diabetes mellitus being massive health problem plaguing in whole world, the disease has affected 285 million adults during 2010 and extrapolation estimates point towards a population of 439 million people to suffer from this disease in 2030. Moreover, the increase would be lopsided being 20-30% in developed countries and 70-80% in the developing countries in this span of 20 years between 2010-2030 (Shaw, 2010) [2].

Sensory evaluation

Sensory acceptability of pasta

Table 1 showed the rating values of various attributes of 9point hedonic scores of developed pasta. In the first step of development of pasta oat flour was used in different proportion (15%, 30%, 45%). Semi trained panel were asked to measure the degree of acceptance of product on the basis of color, appearance, flavour,

texture, taste and overall acceptability. Incorporation of oat in pasta upto 15% (VA) was superior than standard pasta by the panel members of sensory evaluation. Statistical result showed there was 1% level of significance difference between variant A, B, C as compare to standard.

Table 2 showed the rating values of various attributes of 9point hedonic scores of developed pasta. In this step, bael fruit powder was added in different proportion (5%,10%,15%) in accepted variant A (15%) of oat pasta and again sensory evaluation was done on 9- point hedonic scale and it was found variant A of 5% bael fruit powder was more acceptable than standard and other two variants.

Statistical test was used to compared the mean of variant A, B, C as compare to standard which was found statistically significant ($P \leq 0.05$)

These functional ingredients providing a nutritionally enriched product without further impairment on pasta quality.

The addition of oat and bael fruit powder to pasta effectively enhanced the sensory parameters of the pasta and resulted in an upgrading of pasta as a functional food also.

Table 1: Sensory acceptability scores of developed Pasta incorporated with oat flour

Attribute	Standard	VA (15%)	VB (30%)	VC (45%)
Color	8.11±0.51	8.53±0.22	7.92±0.47	7.61±0.00
Appearance	8.11±0.51	8.53±0.22	7.87±0.44	7.77±0.30
Flavour	7.77±0.36	8.53±0.22	7.72±0.30	7.59±0.39
Texture	7.72±0.30	8.49±0.30	7.97±0.48	7.54±0.44
Taste	7.72±0.30	8.49±0.30	7.82±0.41	7.63±0.32
O.A	7.72±0.40	8.49±0.28 ^S	7.72±0.42 ^S	7.59±0.38 ^S

Results are expressed as mean ± SD, ^S: Significant ($p \leq 0.05$), ^{NS}:

Non-significant ($p \geq 0.05$)

Table 2: Sensory acceptability evaluation scores of oat pasta incorporated with bael fruit powder

Attribute	Standard	VA (5%)	VB (10%)	VC (15%)
Color	8.26±0.48	8.57±0.00	7.58±0.22	6.92±0.44
Appearance	8.26±0.48	8.57±0.00	7.97±0.48	7.11±0.51
Flavour	8.02±0.50	8.53±0.22	7.61±0.00	7.07±0.50
Texture	8.02±0.50	8.11±0.51	7.61±0.00	6.89±0.69
Taste	8.02±0.50	8.26±0.48	7.92±0.48	7.21±0.51
O.A	8.02±0.50	8.53±0.29 ^S	7.77±0.36 ^S	7.11±0.43 ^S

Results are expressed as mean ± SD, ^S: Significant ($p \leq 0.05$), ^{NS}:

Non-significant ($p \geq 0.05$)

Materials and Method

Most acceptable variant of pasta i.e. (15% oat + 5% bael fruit powder) were undergone for following nutritional analysis; these were-

A. Proximate composition

a. Estimation of Moisture Content (NIN, 2003)

For 4-6 hours, 10gm of samples were dried in an oven at 100°C. Samples were dried, cooled and weighed precisely until the weight of the samples remained constant.

b. Estimation of Ash (NIN, 2003)

In the crucible, weighed amounts of materials were burnt over a fire. The samples were then thoroughly burned at 600° C for 4 to 5 hrs in a muffle furnace to produce a light grey ash. The samples were weighed after being cooled in a desiccator.

$$\text{Nitrogen } N\% = \frac{14.01 \times 0.1N \times (TV - BV)}{W \times 100} \times 100$$

Calculation

$$\text{Ash (g/100g)} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

$$\text{Carbohydrates } \left(\frac{g}{100g}\right) = 100 - \text{total values\% (moisture + ash + crude protein + fat + fibre)}$$

B. Phytochemical analysis

■ Preparation of water extract

C.

Estimation of Protein by (Sadasivam and Manickam, 1996) [6]

Total protein content was estimated by multiplying Total Kjeldhal Nitrogen (TKN) by a 6.25 conversion factor for mixed diet. The TKN was calculated by digesting a known amount of material at 420° C with a catalyst mixture (potassium sulphate (K₂SO₄) and copper sulphate (CuSO₄)) and conc. H₂SO₄. In the presence of NaOH, the clear solution was distilled. After that, 0.1 N HCl was used to titrate the samples.

Calculation

$$\text{Nitrogen } N\% = \frac{14.01 \times 0.1N \times (TV - BV)}{W \times 100} \times 100$$

$$\text{Protein P (\%)} = \%N \times 6.25$$

d. Fat estimation by (Sadasivam and Manickam, 1996) [6] A weighed amount of samples were placed in a thimble and placed in the soxhlet apparatus, where they were extracted with fat solvent and then the solvent (diethyl ether) was evaporated at 37°C and the percentage of fat content measured.

Calculation

$$\text{Fat (\%)} = \frac{W_2 - W_1}{SW} \times 100$$

Where

W₁ = Initial wt. of the beaker

W₂ = Final wt. of the beaker

SW = Weight of sample

e. Estimation of Crude fibre (Sharma, 2007) [7] To estimate fibre, fat-free samples were boiled for 30 minutes in conc. hydrochloric acid, filtered, then boiled for 30 minutes in conc. NaOH solution. Samples were then dried in the oven and weighed (W₁). They were then placed in a preheated muffle furnace for 2-3 hrs at 600°C to convert to ash and then weighed again (W₂).

Calculation

$$\text{Crude Fiber} = \frac{W_1 - W_2}{W \text{ (weight of sample)}} \times 100$$

Estimation of Carbohydrate (Raghuramulu *et al*, 2003)

The calculation of plant carbohydrate content is done by deducting the total of moisture, protein, fat, ash, and crude fibre from 100 and expressed as carbohydrate (g/100g) content.

Calculation

10g pasta powder was successively dissolved in 200ml water in a beaker. The extract was evaporated to dryness in a rotary evaporator or water bath for 72 hours. The obtained extract was stored in a refrigerator at 4°C until used. Total phenols were determined by using folin-ciocalteu spectrophotometric method [Gao *et al*, 2000] ^[9]. Phytic acid as described by Sadasivam and Manickam (1992) ^[6]. Oxalic acid, flavonoids, Yadav and Agrawal (2011) ^[10]. Alkaloids, saponins, tannins, Wadood *et al*, (2013) ^[11] were also estimated.

C. Differential nutrient component and Lipid profile

Among fatty acids, amount of omega-6, omega-3 and conjugated linoleic acid in the pasta were estimated by GCMS method as described by Alonso *et al*, (2004) ^[12].

D. Calculation of Glycemic index

The glycemic index of oat + bael fruit powder pasta was calculated by the method of Jenkins *et al*, 2002 ^[13]. Five healthy females (25-28 year age) individuals having normal glycemic index of Banasthali vidyapith were recruited. 50g of glucose dissolved in 250ml of water as control diet was given to each individual on the first day after overnight fasting (10-12 hrs). Blood glucose level was checked for two hours. Next day a weighed amount of pasta equivalent to 50g of carbohydrate were given to each individual by following same pre conditions. Finger prick blood samples were taken to measure blood glucose that was done by ACCU-CHEK active at 0 (fasting), 30, 60, 120 min after ingestion of control and test foods.

GI was calculated by the formula:

$$GI = \frac{\text{AUC for test food}}{\text{AUC for reference glucose}} \times 100$$
Area under the curves were computed by using the following formula:

$$\text{AUC} = 0.25 \times (\text{fasting value}) + 0.5 \times (\text{half hour value}) + 0.75 \times (\text{1hour value}) + 0.5 \times (\text{2hour value}).$$

Calculation of glycemic load (GL)-

GL refines the concept of GI to compute the impact that a carbohydrate containing meal or a single food eaten in a normal portion has on blood sugar.

GL was calculated by the formula:

$$GL = \text{net carbohydrates in a typical serving} \times GI \div 100$$

Results and Discussion

Proximate composition of the most acceptable variant of developed pasta (15% oat with 5% bael fruit powder)

Semolina is made by milling durum wheat (*Triticum durum*) with a high gluten content, and oat is a rich source of bioactive compounds with antioxidant characteristics, resulting in a high-quality end product. Since, the most acceptable pasta was prepared by incorporating 15% oat with 5% bael powder. Data given in table, fig 3 indicating the values of moisture, ash, fat, fiber, protein, carbohydrate present in developed

and standard pasta. Developed pasta had high amount of moisture, ash, fiber and protein followed by standard which differed significantly at 1% level of significance. Fat content was approximately same in developed $1.27 \pm 0.00 \text{g}/100\text{g}$ and standard pasta ($1.11 \text{g}/100\text{g}$). Carbohydrate content was significantly high at 1% level of significance in standard pasta ($83.68 \pm 0.00 \text{g}/100\text{g}$) as compared to developed one ($77.60 \pm 0.16 \text{g}/100\text{g}$).

Table 3: Proximate composition of the most acceptable variant of pasta (15% oat with 5% bael fruit powder)

Nutrients	Standard	Developed pasta
Moisture (g/100g)	7.88 ± 0.48	11.1 ± 0.01^s
Ash (g/100g)	0.90 ± 0.01	1.37 ± 0.00^s
Fat (g/100g)	1.11 ± 0.00	1.27 ± 0.00^s
Fiber (g/100g)	1.21 ± 0.01	1.44 ± 0.00^s
Protein (g/100g)	5.23 ± 0.01	7.38 ± 0.00^s
Carbohydrate (g/100g)	83.68 ± 0.00	77.44 ± 0.16^s

Results are expressed as mean $\pm$ SD, ^s: Significant ($p \leq 0.05$), ^{NS}:

Non-significant ($p \geq 0.05$)

Phytochemical composition of most acceptable variant of developed pasta (15% oat with 5% bael fruit powder) Table 4.8(c) illustrate the values of total phenols, phytic acid, oxalic acid, flavonoids, alkaloids, saponins and tannins. Total phenols content was higher in developed bread ($11.1 \pm 0.00 \text{mg}/100\text{g}$) as compared to standard ($3.5 \pm 0.02 \text{mg}/100\text{g}$). ($1.28 \pm 0.00 \text{mg}/100\text{g}$) of phytic acid was found to present in developed pasta which is comparatively higher than standard pasta ($0.13 \pm 0.02 \text{mg}/100\text{g}$). A low amount of oxalic acid was present in developed as well as in standard pasta. Approximately same amount of flavonoids were present in both types of pasta. $4.8 \pm 0.00 \text{mg}/100\text{g}$ of alkaloids were present in modified pasta which observed to be higher as compared to standard pasta ($2.52 \pm 0.05 \text{mg}/100\text{g}$). Amount of saponins present in standard pasta was $1.36 \pm 0.09 \text{mg}/100\text{g}$ and in developed pasta it was $1.03 \pm 0.00 \text{mg}/100\text{g}$. ($2.13 \pm 0.04 \text{mg}/100\text{g}$) of tannins found to present in developed pasta which is comparatively higher than control pasta ($1.42 \pm 0.02 \text{mg}/100\text{g}$). Statistical analysis was used to compare the mean values of all antinutrients between developed and control pasta, which was found statistically significant at 5% level of significance.

Table 4: Phytochemical content of most acceptable variant of developed pasta

Antinutrients	Standard	Developed pasta
Total phenols (mg/100g)	3.5±0.02	11.1±0.00 ^s
Phytic acid (mg/100g)	0.13±0.02	1.28±0.00 ^s
Oxalic acid (mg/100g)	0.26±0.01	0.61±0.00 ^s
Flavonoids (mg/100g)	1.37±0.12	1.86±0.01 ^s
Alkaloids (mg/100g)	2.52±0.05	4.8±0.00 ^s
Saponins (mg/100g)	1.36±0.09	1.03±0.00 ^s
Tannins (mg/100g)	1.42±0.02	2.13±0.04 ^s

Results are expressed as mean ± SD, ^s: Significant (p≤0.05), ^{NS}:

Non-significant (p≥0.05)

Differential carbohydrate composition and lipid profile of most acceptable variant of developed pasta (15% oat with 5% bael fruit powder)

From the data given in Table 5 was evident that the amount of soluble starch, amylose, amylopectin, resistant starch, omega- 6- fatty acid, omega -3- fatty acid and conjugated linoleic acid of 15% oat with 5% bael fruit pasta. Developed pasta was found to have highest soluble starch followed by standard. Amylose content was high in developed pasta (11.57±0.00g/100g) as compared to standard one (7.36±0.00g/100g). (25.12±0.00g/100g) of amylopectin present in standard pasta which was comparatively lower than developed pasta (32.17±0.00g/100g).

(10.57±0.01g/100g) of resistant starch present in developed pasta which was comparatively higher than standard one 8.93±0.00g/100g. Lipid profile were near about similar in both pasta. Statistical result of nutrient content showed there was 1% level of significance {v ratio is greater than 8.185 (f table 1%)} difference in estimated mean of standard and developed pasta.

Table 5: Differential carbohydrate composition and lipid profile of most acceptable variant of developed pasta

Nutrients	Standard	Developed Pasta
Soluble starch (g/100g)	36.4±0.00	48.8±0.00 ^S
Amylose (g/100g)	7.36±0.00	11.57±0.00 ^S
Amylopectin (g/100g)	25.12±0.00	32.17±0.00 ^S
Resistant starch (g/100g)	8.93±0.00	10.57±0.01 ^S
Omega -6 (mg/100g)	5.23±0.00	6.88±0.00 ^S
Omega -3 (mg/100g)	0.12±0.00	0.34±0.00 ^{Ss}
CLA (mg/100g)	3.36±0.09	4.9±0.01 ^S

Results are expressed as mean ± SD, ^S: Significant (p≤0.05), ^{NS}: Non-significant (p≥0.05)

Glycemic index and glycemic load of most acceptable variant of pasta incorporated 15% oat with 5% bael fruit powder-

Low glycemic index foods include durum wheat pasta. The desire to make enriched pasta has grown in recent years. Because both the formulation and processing processes have the potential to impact the GI tract. Functional additives can be added to enriched pasta, as functional food consumption has expanded in recent years. Their consumption should give health benefits beyond basic nourishment due to their physiologically active components.

It was observed that glycemic index and load of oat-bael (15% oat flour + 5% bael fruit powder) was estimated and compared with the values of standard pasta. Glycemic index value of developed pasta was 55.0 ±1.70 and glycemic load was 27±0.83. On the other hand, glycemic index value of control pasta was 60.6±2.06 and glycemic load was 30.3±1.03. The data indicate that the oat and bael fruit powder pasta was in the category of low GI food items. While control pasta was in the category of high glycemic index and glycemic load. GI and GL of standard and developed pasta differ significantly at 1% level of significance.

Conclusion

The occurrence of associated complication depends the success of glycemic control over the time. So, intake of low glycemic food plays a significant role to control elevated blood sugar. The research focuses on very

popular and most consumed food product: pasta which not only add a variety in the food choices in diabetic patients but their long-term use may be proved beneficial to them.

Acknowledgement

We are thankful to the department of Community science of Banasthali vidyapith for providing the laboratory facilities and valuable guidance.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

- Bordoloi, R., & Dutta, K. N. (2014). A review on herbs used in the treatment of diabetes mellitus. *Journal of Pharmaceutical, Chemical and Biological Sciences*, 2(2), 86–92.
- Shaw, J. E., Sicree, R. A., & Zimmet, P. Z. (2010). Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Research and Clinical Practice*, 87(1), 4–14. <https://doi.org/10.1016/j.diabres.2009.10.007>
- Chawla, R., Thakur, P., Chowdhry, A., Jaiswal, S., Sharma, A., Goel, R., ... Arora, R. (2013). Evidence-based herbal drug standardization approach in coping with challenges of holistic management of diabetes: A dreadful lifestyle disorder of 21st century. *Journal of Diabetes & Metabolic Disorders*, 12(1), 1–16. <https://doi.org/10.1186/2251-6581-12-35>
- Patil, R. N., Patil, R. Y., Ahirwar, B., & Ahirwar, D. (2011). Evaluation of antidiabetic and related action of some Indian medicinal plants in diabetic rats. *Asian Pacific Journal of Tropical Biomedicine*, 1(4), 316–320. [https://doi.org/10.1016/S2221-1691\(11\)60050-4](https://doi.org/10.1016/S2221-1691(11)60050-4)
- National Institute of Nutrition (NIN). (2003). *A manual of laboratory techniques*. Indian Council of Medical Research.
- Sadasivam, S., & Manickam, A. (1996). *Biochemical methods* (2nd ed.). New Age International (P) Ltd., Publishers.
- Sharma, S. (2007). *Experiments and techniques in biochemistry*. Galgotia Publication Pvt. Ltd.
- Raghuramulu, N., Nair, K. M., & Kalyanasundaram, S. (2003). *A manual of laboratory techniques* (2nd ed., pp. 56–58). National Institute of Nutrition, India.
- Gao, X., Björk, L., Trajkovski, V., & Ugglä, M. (2000). Evaluation of antioxidant activities of rosehip ethanol extracts in different test systems. *Journal of the Science of Food and Agriculture*, 80(14), 2021–2027. [https://doi.org/10.1002/1097-0010\(200011\)80:14<2021::AID-JSFA745>3.0.CO;2-9](https://doi.org/10.1002/1097-0010(200011)80:14<2021::AID-JSFA745>3.0.CO;2-9)

- Yadav, R. N. S., & Agrawal, M. (2011). Phytochemical analysis of some medicinal plants. *Journal of Phytology*, 3(12), 10–14.
- Wadood, A., Ghufuran, M., Jamal, S. B., Naeem, M., Khan, A., Ghaffar, R., & Asnad. (2013). Phytochemical analysis of medicinal plants occurring in local area of Mardan. *Biochemistry and Analytical Biochemistry*, 2(4), 1–4. <https://doi.org/10.4172/2161-1009.1000144>
- Alonso, L., Cuesta, E. P., & Gilliland, S. E. (2004). Gas chromatographic method for analysis of conjugated linoleic acids isomers (c9t11, t10c12, and t9t11) in broth media as application in probiotic studies. *Journal of Chromatographic Science*, 42(4), 167–170. <https://doi.org/10.1093/chromsci/42.4.167>
- Jenkins, A. L., Jenkins, D. J. A., Vuksan, V., Wursch, P., & Jeffcoat, R. (2002). Depression of the glycemic index by high levels of beta glucan fiber in two functional foods tested in type 2 diabetes. *European Journal of Clinical Nutrition*, 56(7), 622–628. <https://doi.org/10.1038/sj.ejcn.1601355>