BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, June 2023. Vol. **20**(2), p. 591-597

In-Vivo Efficacy of Buckwheat Flour Incorporated Food Products on the Blood Glucose and Lipid Profiles

G.K. Gomathi[1], S. Parameshwari[1]* and M.G. Uvaraj[2]

[1]Department of Nutrition and Dietetics, Periyar University, Salem, Tamil Nadu, India.
[2]M G Diabetes Speciality and Research Centre, Salem-4, India.

http://dx.doi.org/10.13005/bbra/3112

(Received: 05 January 2023; accepted: 27 February 2023)

Buckwheat, a pseudo-cereal, was processed into flour and incorporated in food products like chapatti, nutri balls, and soup mix. The supplementation of three developed food products to three groups with 15 subjects (with diabetes and dyslipidemia) in each group was carried out for 90 days, while one group (15 subjects) was treated as a control where no intervention was given. The blood sugar profile and blood lipid profile including the levels of fasting blood sugar, post-prandial blood sugar, HbA1c, serum cholesterol, triglycerides, Low-Density Lipoprotein, High-Density Lipoprotein, and Very Low-Density Lipoprotein were assessed before and after the supplementation period and subjected to statistical analysis. The results depict that in the experimental group supplemented with buckwheat flour incorporated chapatti, a significant difference ($p<0.05$) was observed in all the biochemical parameters assessed, while in the group supplemented with buckwheat flour incorporated nutri ball, a significant difference ($p<0.05$) was observed in the HbA1C levels, serum triglyceride levels, and LDL levels. The group supplemented with buckwheat flour incorporated soup mix showed a significant difference ($p<0.05$) in the fasting blood sugar levels, postprandial blood sugar levels, serum triglyceride levels, and LDL levels. Hence, it can be concluded that the consumption of buckwheat flour has a significant impact on blood sugar and lipid profile.

Keywords: Buckwheat; Diabetes; Dyslipidemia; Low gluten foods; Pseudocereal.

Buckwheat, potential functional food, is mainly consumed as grains or flour. The concept of value addition to foods has increased the use of underutilized pseudo-cereals like buckwheat in bakery foods and convenience foods[1]. In recent times, buckwheat sprouts are also available for consumption[2]. Also, buckwheat being gluten-free, can be highly recommended for subjects with gluten intolerance or celiac disease. Buckwheat is found to be a good source of proteins (80% digestibility), lipids, dietary fiber, flavonoids especially rutin, phenolic acids, B-complex vitamins, isoprenoids, phagopyritols, sterols, iminosugars, and hence has gained focus as a functional food by lowering cholesterol levels, glucose levels, anticancer and anti-inflammatory activity[3,4]. Research has thrown a positive light on the health benefits attained by consuming buckwheat and buckwheat-enriched food products in both, in-vitro and in-vivo studies[5]. The bioactive components in buckwheat with abundant biotic functions have renewed the curiosity to source its utilization as an alternative crop[6]. A systemic review has shown that buckwheat supplementation had significantly decreased blood

*Corresponding author E-mail: arameshwari@periyaruniversity.ac.in

glucose and lipid levels when compared with controls[7].

Though, buckwheat is a source of the aforementioned nutrients, the processing techniques pose a question of the bioavailability of the nutrients. In this study, buckwheat is processed to flour by milling, which is a widely perceived technique, where, the husk and outer layers are separated, thus the ratio of fibers, minerals, and polyphenolic compounds becomes lower[8]. Hence, to overcome the incongruities in the nutritional values, the bran was added to the flour after milling and the whole buckwheat flour was used for incorporation into the food products.

The heat treatment employed for the preparation of buckwheat flour-enriched bakery products like bread and cakes and in the formulation of extruded products like noodles, pasta, and spaghetti, resulted in a decrease in the bioactive components[9]. With an insight into the nutritional components and the losses that occur during food formulations due to extraneous factors, in this study, we have considered the development of food products like chapatti, nutri ball, and soup mix, which involve less processing and hence more health benefits are reserved.

MATERIALS AND METHODS

Selection and processing of ingredients

The raw materials required for the formulation of buckwheat flour incorporated food products, namely, buckwheat, wheat, peanuts, corn starch, salt and powders of onion, tomato, garlic, milk, pepper, and carrot were procured from the local supermarket in Salem. Buckwheat and wheat were milled to flour.

Formulation of buckwheat flour incorporated food products

Three different food products viz. chapattis, nutri balls, and soup mix were formulated by incorporating 30% buckwheat flour in the standard recipe.

Selection of Subjects for Supplementation

Ethical clearance for human supplementation studies was obtained from the Institutional Ethics Committee at Government Mohan Kumaramangalam Medical College and Hospital, Salem, Tamil Nadu, India (Ref. No. GMKMC&H/4341/IEC/2019-297) dated 16.3.2020.

The diabetic subjects with dyslipidemia for supplementation were selected from M.G. Diabetes Specialty and Research Centre, Salem, Tamil Nadu, India. The subjects were selected from the heterogeneous population of all economic groups with different occupations in Salem city. A hundred subjects aged between 45 to 60 years were selected. Internationally accepted tools based on earlier studies were selected for data collection.

Supplementation of buckwheat flour incorporated food products on the selected diabetic **subjects with dyslipidemia**

All three developed food products, namely 30% buckwheat flour incorporated chapatti, nutri ball and soup mix were chosen for supplementation. Out of 100 subjects, 60 voluntary subjects were randomly selected and divided into four groups as mentioned below:

Group I: Control Group (15 subjects) – No intervention

Group II: Experimental group (15 subjects) – Buckwheat flour incorporated chapatti

Group III: Experimental group (15 subjects) – Buckwheat flour incorporated nutri balls

Group IV: Experimental group (15 subjects) – Buckwheat flour incorporated soup mix

Supplementation was carried out for three months.

Assessment of the blood sugar and lipid profile of the selected subjects before and after supplementation

Biochemical parameters like Fasting blood sugar, Postprandial blood sugar, HbA1c, Serum cholesterol, Triglycerides, Low-Density Lipoprotein (LDL), High-Density Lipoprotein (HDL), and Very Low-Density Lipoprotein (VLDL) of the subjects were analyzed by standard procedures before and after supplementation of 30% buckwheat flour incorporated chapattis, nutri balls, and soup mix.

Statistical Analysis

The mean values were subjected to t-tests to determine the significant difference in the impact of supplementation of buckwheat flour incorporated food products on the blood glucose and lipid profile of the selected subjects [10].

RESULTS AND DISCUSSION

Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the blood glucose profile of the selected subjects

The impact of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the blood glucose parameters namely fasting blood sugar, postprandial blood sugar, and HbA1C levels of the selected subjects is discussed.

It is evident from the above table that there is no significant difference in the fasting blood sugar levels of group I (the Control group) where no intervention was carried out and group III, the experimental group where buckwheat flour was incorporated with nutri ball was supplemented. The experimental groups II and IV, in which buckwheat flour incorporated chapatti and soup mix was supplemented respectively showed a significant difference at the 5% level. Also, a 5-week supplementation of 100 grams of buckwheat flour

Table 1. Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the fasting blood glucose levels of the selected subjects

Experimental Groups	Fasting Blood Sugar Before Supplementation Mean ± SD	Fasting Blood Sugar After Supplementation Mean ± SD	T value	Significance
Group I	135.67 ± 6.20	134.47 ± 7.00	0.566	0.580^{NS}
Group II	135.67 ± 6.20	108.40 ± 4.93	82.510	0.000**
Group III	136.87 ± 5.46	132.13 ± 5.92	1.906	0.077^{NS}
Group IV	134.40 ± 6.06	123.27 ± 5.03	4.783	0.000**

**Significant at 5%level ($p<0.05$); NS – Not Significant

Table 2. Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls and soup mix on the post-prandial blood glucose levels of the selected subjects

Experimental Groups	Post Prandial Blood Sugar Before Supplementation Mean ± SD	Post Prandial Blood Sugar After Supplementation Mean ± SD	T value	Significance
Group I	231.73 ± 8.47	234.00 ± 6.84	-0.731	0.477^{NS}
Group II	231.73 ± 8.47	185.47 ± 6.73	102.325	0.00**
Group III	233.00 ± 6.34	227.33 ± 5.40	2.090	0.55^{NS}
Group IV	225.40 ± 28.80	209.80 ± 5.64	2.354	0.034**

**Significant at 5%level ($p<0.05$); NS – Not Significant

Table 3. Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the HbA1C levels of the selected subjects

Experimental Groups	HbA1C levels Before Supplementation Mean ± SD	HbA1C levels After Supplementation Mean ± SD	T value	Significance
Group I	8.30 ± 0.71	8.48 ± 0.90	1.120	0.282 ^{NS}
Group II	8.24 ± 0.55	6.65 ± 0.50	14.814	0.000**
Group III	8.86 ± 0.89	8.64 ± 0.82	5.724	0.000**
Group IV	8.72 ± 0.81	7.90 ± 0.65	7.550	0.000**

**Significant at 5%level ($p<0.05$); NS – Not Significant.

on diabetic patients reduced fasting blood glucose levels[11].

The above table depicts that there is no significant difference in the fasting blood sugar levels of group I (Control group) where no intervention was carried out and group III, the experimental group where buckwheat flour incorporated nutri ball was supplemented. The experimental groups II and IV, in which buckwheat flour incorporated chapatti and soup mix was supplemented respectively showed a significant difference at the 5% level. A cross-sectional buckwheat supplementation study showed a significant reduction in blood glucose levels[12].

Table 3 signifies a significant difference in the HbA1C value before and after supplementation in all the experimental groups except the control. The mean difference in the HbA1C levels in experimental group II (Buckwheat flour incorporated chapatti) was found to be higher (1.59) followed by experimental group IV (Buckwheat flour incorporated soup mix) 0.82. A similar study, on supplementation with buckwheat flour for 2 months on diabetic patients showed reduced HbA1C levels[13].

Table 4. Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the serum cholesterol levels of the selected subjects

Experimental Groups	Serum cholesterol levels Before Supplementation Mean ± SD	Serum cholesterol levels After Supplementation Mean ± SD	T value	Significance
Group I	211.67 ± 7.28	206.87 ± 5.70	1.973	0.069 ^{NS}
Group II	210.53 ± 5.27	188.13 ± 4.48	73.321	0.000**
Group III	210.27 ± 6.80	207.27 ± 4.30	1.329	0.205 ^{NS}
Group IV	204.80 ± 25.71	189.60 ± 6.16	2.379	0.032 ^{NS}

**Significant at 5%level ($p<0.05$); NS – Not Significant

Table 5. Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the serum triglyceride levels of the selected subjects

Experimental Groups	Serum triglyceride levels Before Supplementation Mean ± SD	Serum triglyceride levels After Supplementation Mean ± SD	T value	Significance
Group I	161.00 ± 4.48	162.00 ± 5.14	-0.524	0.608 ^{NS}
Group II	163.67 ± 5.78	147.67 ± 5.62	39.764	0.000**
Group III	163.73 ± 5.79	157.53 ± 6.27	2.242	0.042**
Group IV	160.53 ± 5.74	148.20 ± 14.93	3.479	0.004**

**Significant at 5%level ($p<0.05$); NS – Not Significant

Table 6. Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls and soup mix on the LDL levels of the selected subjects

Experimental Groups	LDL levels Before Supplementation Mean ± SD	LDL levels After Supplementation Mean ± SD	T value	Significance
Group I	160.53 ± 5.75	160.13 ± 5.22	0.234	0.818 ^{NS}
Group II	160.53 ± 5.75	141.20 ± 1.42	12.770	0.000**
Group III	162.00 ± 4.17	156.80 ± 5.25	2.476	0.027**
Group IV	159.80 ± 5.25	146.33 ± 3.69	7.108	0.000**

**Significant at 5%level ($p<0.05$); NS – Not Significant

Table 7. Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the HDL levels of the selected subjects

Experimental Groups	HDL levels Before Supplementation Mean ± SD	HDL levels After Supplementation Mean ± SD	T value	Significance
Group I	40.26 ± 3.10	39.53 ± 3.56	0.577	0.573 ^{NS}
Group II	40.13 ± 3.37	48.20 ± 4.03	44.395	0.000**
Group III	38.66 ± 4.59	41.40 ± 3.37	1.849	0.086 ^{NS}
Group IV	40.40 ± 3.37	42.60 ± 5.12	1.400	0.183 ^{NS}

**Significant at 5%level ($p<0.05$); NS – Not Significant

Table 8. Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the VLDL levels of the selected subjects

Experimental Groups	VLDL levels Before Supplementation Mean ± SD	VLDL levels After Supplementation Mean ± SD	T value	Significance
Group I	52.00 ± 6.62	53.93 ± 5.37	1.025	0.323 ^{NS}
Group II	52.00 ± 6.62	40.33 ± 5.72	9.871	0.000**
Group III	54.40 ± 3.83	51.26 ± 4.31	1.776	0.097 ^{NS}
Group IV	52.13 ± 4.51	49.00 ± 3.42	1.879	0.081 ^{NS}

**Significant at 5%level ($p<0.05$); NS – Not Significant

Effect of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the blood lipid profile of the selected subjects

The impact of supplementation of buckwheat flour incorporated chapattis, nutri balls, and soup mix on the blood lipid parameters namely serum cholesterol, serum triglyceride, LDL, HDL and VLDL levels of the selected subjects are discussed.

The result of serum cholesterol showed that there is a significant difference between before and after supplementation of chapatti, whereas there is no significant difference between the before and after supplementation results of the control group, and experimental groups supplemented with buckwheat flour incorporated nutri ball and soup mix. A 24-week study on participants with high CVD risk, where buckwheat products were supplemented every day showed reduced total cholesterol levels[14]. The decrease in cholesterol levels may be due to the effect of buckwheat protein products on the increased secretion of bile acid, and increased excretion of fecal bile acids[15].

Table 5 shows that the supplementation of all three buckwheat flour incorporated food products had a significant impact on the serum triglyceride levels, while the mean difference between the before and after supplementation triglyceride values was found to be highest (16) in experimental group II supplemented with buckwheat flour incorporated chapatti, followed by group IV (12.33) supplemented with soup mix and group III (6.2) supplemented with nutri ball. A previous research study has stated that 15 grams of buckwheat tea consumption by hyperlipidemic patients for 60 days had shown a significant reduction in the serum triglyceride level[16].

It is evident from the above table that except for the control group (Group I), all the other experimental groups had a significant impact on serum LDL levels. The LDL levels were found to be decreased with a mean difference of 19.33, 13.47, and 5.2 in experimental group II (buckwheat flour chapatti), group IV (buckwheat flour soup mix) and group III (buckwheat flour nutria ball) respectively. Similarly, buckwheat-enriched bread

supplementation for 1 month reduced serum LDL levels[17].

Table 7 depicts that the Serum HDL level was found to increase after the supplementation period only in group II, where the subjects were given buckwheat flour incorporated chapatti. Other groups had no significant difference in HDL levels after supplementation. Research studies state that 100 grams of sieved buckwheat flour preparations consumed and 40 grams of buckwheat flour for 4 weeks raised HDL levels[12, 18, 19].

It is evident from the above table that the VLDL level decreased after the supplementation period only in group II, where the supplemented product was buckwheat flour incorporated chapatti. Other groups had no significant difference in VLDL levels after supplementation. 100 grams of whole buckwheat flour consumed for 12 weeks reduced serum VLDL levels[20].

CONCLUSION

This research study clinches that consistent intake of buckwheat flour-incorporated food products may lower blood glucose and lipid levels. In chapatti, buckwheat along with wheat has more glucose and lipid-lowering effect in comparison with other food products like nutri ball and soup mix, which could be due to the higher fiber content obtained from both buckwheat flour and wheat flour. Buckwheat, being gluten-free, with bioactive components like polyphenols, rutin and quercetin, fiber and a good amount of protein proves to be an apt alternative to commonly consumed grains by adding variety to the daily diet. Hence, it can be concluded the regular consumption of buckwheat or buckwheat-value-added food products promote an array of health benefits, especially hypoglycemic and hypocholesterolemic effects.

ACKNOWLEDGEMENT

The authors wish to acknowledge the support of patients and staff of M.G. Diabetes Specialty and Research Centre, Salem, Tamil Nadu, India, in conducting this study.

Conflict of Interest

The authors declare no conflict of interest.

Source of Funding

The author received no financial support for this research.

REFERENCES

1. Giménez-Bastida J., Piskula M., Zieliński H. Recent advances in processing and development of buckwheat derived bakery and nonbakery products—A review. *Polish Journal of Food and Nutrition Sciences*. 2015;65(1):9-20. DOI: 10.1515/pjfns-2015-0005
2. Sturza A., Paucean A., Chis MS., Mures V., Vodnar DC., Man SM., et al. Influence of buckwheat and buckwheat sprouts flours on the nutritional and textural parameters of wheat buns. *Applied Sciences*. 2020;10(22):7969-69. DOI: 10.3390/app10227969
3. Zhang Z., Zhou M., Tang Y., Li F., Tang Y., Shao J., et al. Bioactive components in functional buckwheat food. *Food Research International*. 2012;49(1):389-95. DOI: 10.1016/j.foodres.2012.07.035
4. Yilmaz H.O., Ayhan N.Y., Meric C.S. Buckwheat: A Useful Food and its Effects on Human Health. *Current Nutrition and Food Science*. 2020;16:29-34. DOI: 10.2174/1573401314666180910140021
5. Ji X., Han L., Liu F., Yin S., Peng Q., Wang M. A mini-review of isolation, chemical properties and bioactivities of polysaccharides from buckwheat (Fagopyrum Mill). *International Journal of Biological Macromolecules*. 2019;127:204-09. DOI: 10.1016/j.ijbiomac.2019.01.043
6. Džafiæ., Amela., Žuljeviæ., Sanja. "The Importance of Buckwheat as a Pseudocereal: Content and Stability of Its Main Bioactive Components". Pseudocereals, edited by Viduranga Waisundara, *IntechOpen*, 2022. 10.5772/intechopen.102570. DOI: 10.5772/intechopen.102570
7. Li L., Lietz G., Seal C. Buckwheat and CVD Risk Markers: A Systematic Review and Meta-Analysis. *Nutrients*. 2018;10(5):619. DOI: 10.3390/nu10050619. PMID: 29762481; PMCID: PMC5986499.
8. Chen X.W., Chen Y.J., Li J.Y., Wang Y.H., Yang X.Q. Enzyme-assisted development of biofunctional polyphenol-enriched buckwheat protein: Physicochemical properties, in vitro digestibility, and antioxidant activity. *Journal of the Science of Food and Agriculture*. 2019;99(6):3176-85. DOI: 10.1002/jsfa.9534

9. Verardo V., Arrárez-Román D., Segura-Carretero A., Marconi E., Fernández-Gutíerrez A., Fiorenza CM. Determination of free and bound phenolic components in buckwheat spaghetti by RP-HPLC-ESI-TOF-MS: Effect of thermal processing from farm to fork. *Journal of Agricultural and Food Chemistry*. 2011;59(14):7700-07. DOI: 10.1021/jf201069k
10. IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.
11. Lin R., Jia W., Ren J. Research and utilization of Tartary buckwheat. In: Corke H., Lin R., editors. Proceeding from the International Conference Asian Product Development. Science Press; Shanxi, Taiyuan, China: 1998. pp. 187–197.
12. Zhang H., Zhang Y., Lu M., Tong W., Ao Y., Zhao Y., Li J., Bao J. Effects of buckwheat-eating on blood sugars and serum lipids levels and blood pressure. J. Environ. *Occup. Med.* 2003;20:120-22.
13. Huang G., Huang M., Chen W., Huang Y., Yang Z., You Y. Clinical effects of tartary buckwheat mixture on the treatment of early diabetic and nephropathy. *J. Chin. Med. Mater*. 2009;32:1932-35.
14. Dinu M., Ghiselli L., Whittaker A., Pagliai G., Cesari F., Fiorillo C., Becatti M., Marcucci R., Benedettelli S., Sofi F. Consumption of buckwheat products and cardiovascular risk profile: A randomized, single-blinded crossover trial. *Nutr. Metab. Cardiovasc. Dis*. 2017; 27:e20–e21. DOI: 10.1016/j.numecd.2016.11.054.
15. Tomotake H., Yamamoto N., Kitabayashi H., Kwakami A., Kayashita J., Ohinata H., Karasawa H., Kato N. Preparation of tartary buckwheat protein product and its improving effect on cholesterol metabolism in rats and mice fed cholesterol-enriched diet. *J. Food Sci*. 2007; 72:S528-33. DOI: 10.1111/j.1750-3841.2007.00474.x.
16. Yu F. Observation of the hypolipidemic effects of Tartary buckwheat tea. *J. Today Health*, 2015;4:283.
17. Stokiæ E., Mandic A., Sakac M., Misan A., Pestoric M., Simurina O., Jambrec D., Jovanov P., Nedeljkovic N., Milovanovic I., et al. Quality of buckwheat-enriched wheat bread and its antihyperlipidemic effect in statin treated patients. *LWT Food Sci. Technol*. 2015;63:556–61. DOI: 10.1016/j.lwt.2015.03.023.
18. Bijlani R.L., Sud S., Sahi A., Gandhi B.M., Tandon B.N. Effect of sieved buckwheat (Fagopyrum esculentum) flour supplementation on lipid profile and glucose tolerance. *Indian J. Physiol. Pharmacol*. 1984;29:69–74. PMID: 2989169
19. Liu X., Fu X. Randomized clinical trial of Tartary buckwheat's curing effect on elderly hyperlipidemia. Acad. Pap. Complies Chin. Nutr. Soc. Conf. 1996;7:184-85.
20. Bijlani R.L., Gandhi B.M., Gupta M.C., Manocha S., Tandon B.N. Effect of whole buckwheat (Fagopyrum esculentum) flour supplementation on lipid profile & glucose tolerance. *Indian journal of medical research*. 1985;81:162-68. PMID: 2989169