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Nandana Kumari
Scientist (Home Science) KVK, Bokaro. Jharkhand, India

Rita Singh Raghuvanshi
Dean, College of Home Science, Department of Foods and Nutrition, GBPUAUT. Pantnagar, Uttarakhand, India

Correspondence
Nandana Kumari
Scientist (Home Science) KVK, Bokaro. Jharkhand, India

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Buckwheat (*Fagopyrum esculentum*) as an emerging functional food for hypertension

Nandana Kumari and Rita Singh Raghuvanshi

Abstract
Non communicable diseases (NCDs) are now dominant sources of mortality around the globe. Among NCDs, hypertension is the most widely prevalent non-communicable disease in developing countries including India**.** These facts have necessitated the need of functional foods which can be used to combat high prevalence of hypertension. In Uttarakhand state, Buckwheat (*Fagopyrum esculentum*) is a traditional and underutilized crop which is very nutritious with immense health benefits. Buckwheat leaves are consumed by local hill people but its grains are less used as food, mainly during religious fast only. Therefore, a study was conducted with the objective to see the effect of buckwheat on blood pressure of hypertensive subjects at Pantnagar of Uttrakhand state. Forty five hypertensive subjects selected randomly and divided into three groups, as control, placebo and experimental group, each group composed of 15 subjects. After the collection of baseline information, dietary intervention programme was launched with the help of buckwheat based experiment food continuous for 90 days. For this purpose, local variety of buckwheat grains purchased from nearby villages of Gwaldum district. Buckwheat grains was made into flour and experiment food was developed in the form of 100 g (each packet)of flour mix (consisted of whole wheat flour and whole buckwheat grain flour in 1:1 ratio).Blood pressure was measured before and after the dietary intervention programme. After the dietary intervention programme, the per cent change in systolic pressure were 10.07 (+), 4.30 (+) and 6.76 (-) and the per cent change in diastolic pressure were 3.85(+), 4.17(+) and 7.47(-) in the hypertensive subjects of control, placebo and experimental group respectively. The change found in the systolic and diastolic blood pressure in the subjects of control and placebo group was undesirable whereas of experimental group, the change was desirable and statistically significant (p0.05) also. It was very clear that the regular consumption of buckwheat based experiment food lead to significant fall in blood pressure in experimental group which was the impact of buckwheat because there were no change in all other influencing factors like diet pattern, medicine use and life style etc in all hypertensive subjects. So, it can be concluded that buckwheat had blood pressure lowering effect. Therefore, various buckwheat based health foods could be developed as functional foods which would be beneficial for hypertensive subjects.

Keywords: Non-communicable diseases, hypertension, functional foods, buckwheat, blood pressure, dietary intervention programme.

Introduction
Non communicable diseases are now dominant sources of mortality around the globe. That's why, the global attention has turned towards non communicable diseases. Epidemics of non-communicable diseases are presently accelerating in most developing countries including India. Hypertension is the most widely prevalent non-communicable disease and the most common factor responsible for Ischemic Heart Diseases (IHD) and Cerebro-vascular accidents. A seven year average follow-up study showed an accelerated rise of all cause mortality in the population with systolic BP≥110 mm Hg and diastolic BP≥80 mm Hg. Stroke mortality started to increase after diastolic BP≥75 mm Hg (http://203.90.70.117//PDS_DOCS/B4793.pdf). According to Gupta *et al.*, (2008) in India,

hypertension is directly responsible for 57 per cent of all stroke death and 24 per cent of all coronary heart disease deaths (http://wwww.ijmr.org.in cited on 2-10-2012). In India, 10% of attributable (around 7.1 million) deaths are due to hypertension (www.icmr.nic. in cited on 11-8-2012).

Need of the Hour: Functional Food

These facts have necessitated the need of functional food items with high content of nutrients and potential health benefits so that they can be used to prevent the high prevalence of hypertension through simple, suitable and cost effective way. The interest in functional foods has resulted in a number of new foods in the marketplace designed to address specific health concerns, particularly related to chronic diseases. Functional foods represent one of the most intensively investigated and widely promoted areas in the food and nutrition sciences today. In addition to new foods designed specifically to enhance health, however, functional foods can also include those traditional, familiar foods for which recent research findings have highlighted new health benefits. For the food industry, the most attractive trend is development of new functional foods.

Buckwheat: As an Emerging Functional Food

Buckwheat (*Fagopyrum esculentum*) is basically a traditional and uncultivated crop but very nutritious with immense health benefits. Buckwheat has been grown for centuries and now it is one of the most important alternative crops and a valuable raw material for functional food production. Buckwheat is an excellent example in this field. Buckwheat is one such crop whose leaves are generally consumed by local hill people but its grains are less used as food, mainly during religious fast only. Many nutraceutical compounds exist in buckwheat seeds and other tissues. It is a rich source of starch and contains many valuable compounds, such as proteins, antioxidants, trace elements and dietary fibre. Buckwheat proteins have unique amino acids composition with special biological activities. Besides high- quality proteins, buckwheat seed contain several components with healing benefits: flavonoids, flavones, phytosterols and fagopyrins.

Nutrient composition and health benefit of buckwheat

Studies conducted have shown that its grain has comparable calorific value to wheat and rice, are rich source of Zinc, Calcium, Magnesium, Iron, Copper, Selenium and Sodium than wheat grain. It has high methionine (9.6%) and lysine content (5.6%) in its protein content and are rich source of flavonoids especially rutin. Its leaves are also rich of flavonoids. In recent years, it has gained importance in clinical applications being increasingly recognised in the prevention and maintenance of several degenerative diseases. Buckwheat leaves have been found to be beneficial in regulating blood pressure and controlling damage to retina from radiation. Buckwheat is considered as coarse cereal and it is highly nutritive and having complex carbohydrate. It is rich in lysine, unlike other cereals which are deficient in lysine, one of the essential amino acid for human health.

Barakoti (2010) [2] conducted a study in US Nagar district of Uttarakhand state and found that among 100 hypertensive subjects, 31.0 per cent male and 35.7 per cent female had family history of hypertension. So, it is the need of hour to reduce the high prevalence of hypertension to save the mankind though dietary approaches. Recognizing the health benefits and nutrient content, buckwheat can play an important role in overcoming hypertension by its therapeutic role. By considering all above points, the present study, therefore, has been undertaken with the objective: to study the impact of buckwheat based flour on blood pressure of hypertensive subjects.

Materials and Methods

A series of activities were conducted in the methodology of the study. Stepwise details of activities are given below.

Selection of Hypertensive Subjects

For getting the list of hypertensive subjects, regular doctors of Pantnagar University Hospital were contacted. Local pathology of Pantnagar as well as community persons was also approached. All hypertensive subjects were randomly selected.

Selection Criteria for Subjects

Adult hypertensive persons either male or female having more than 20 years of age been selected as subjects for the study. Among female hypertensive subjects, only NPNL female subjects were selected. Only those hypertensive subjects were selected who voluntarily agreed to participate in the study and a written consent was obtained from them.

Development of Tool for Data Collection

A pre-structured survey schedule was prepared. The survey schedule was pre-tested on non-sample group of pantnagar. After, pre-testing, proper modifications were done and the final survey schedule was developed. With the help of survey schedule, baseline information was collected.

Assessment of Blood Pressure of Hypertensive Subjects

Blood pressure was measured in sitting position using mercury sphygmo-manometer and measurement was done of three consecutive times with a gap of five minutes between measurements (www.nnmbindia.org cited on 23-7-2012). Blood pressure was measured before and after the dietary intervention programme.

Dietary Intervention Programme for Hypertensive Subjects

The primary objective of the present investigation is to see the impact of buckwheat based dietary intervention on blood pressure of the hypertensive subjects.

Preparation of Buckwheat Flour

Whole lot of buckwheat grains were thoroughly cleaned, made free from dust and foreign materials and kept for sun-drying for few hours. Then sun-dried buckwheat grains were kept for oven drying (in hot air oven) at 45 degree centigrade for 8 hour to prevent deterioration from biological agents such as insects and moulds during the course of dietary intervention. The well dried grains were subjected to grinding. Thereafter, the grinded buckwheat flour is sieved through 40 mesh sieve and stored in clean, dry and airtight containers for dietary intervention purpose.

Selection of Food Medium for Dietary Intervention

For finding a suitable medium for dietary intervention, all round factors like their food habits, dietary pattern, availability of buckwheat and its processing facilities in local areas of the study region were considered. By considering all these factors, chapatti, a widely consumed food item, in all kinds of meal whether breakfast, lunch or dinner, was selected as a medium for dietary intervention programme.

Sensory Evaluation of Buckwheat Based Chapatti

Since chapatti cannot be prepared by using sole buckwheat flour because buckwheat lacks gluten, the binding complex, present in wheat flour. For finding proper combination of mixing of buckwheat flour and wheat flour, sensory evaluation of three different combinations was done through score card method, first as 60:40 ratio, second as 50:50 ratio and third as 40:60 ratio of buckwheat and wheat flour. Chapatti were prepared by using all the three combinations and evaluated. After sensory evaluation, it was decided that most suitable combination of mixing buckwheat flour and wheat flour was 50:50 ratio. Experiment food was prepared by using this combination. All hypertensive subjects were properly guided regarding method of buckwheat based value added chapatti making in the same way as the traditional wheat chapattis are made.

Experimental Design for Dietary Intervention

Forty five (45) hypertensive subjects were randomly selected and all 45 subjects were divided into three groups and each group composed of 15 hypertensive subjects. First 15 subjects composed control group, another 15 subjects formed placebo group and third group of again 15 subjects were part of experimental group. Placebo group and experimental group received placebo and experimental food which was made of whole wheat grain flour only (100 g in well sealed polythene packets/day for each subject) and mixture of whole buckwheat grain flour and whole wheat grain flour in 50:50 ratio (in well-sealed polythene packets of 100g/day for each subject) while control group did not get any kind of experimental food. Each subject of either placebo group or experimental group were properly instructed to take experimental /placebo food of 100 gram daily for three months (for 90 days)either in breakfast, lunch or dinner in the form of chapatti. Regular monitoring of dietary intervention was done. The data was analyzed for percentage, mean, standard deviation, paired-t test, one way ANOVA and two way ANOVA.

Results and Discussion

Blood pressure has two components, one systolic and other diastolic blood pressure. The study subjects of the control, placebo and experimental group were checked for their systolic and diastolic blood pressure before the start of intervention and after the culmination of the intervention which was for 90 days and the impact assessment was done on both systolic and diastolic blood pressure of hypertensive subjects. The findings of the study is given in Table 1, Table 2 and Table 3.

Distribution of Hypertensive Subjects According to Systolic Pressure Classification (JNC VII, 2003):

All hypertensive subjects were distributed into four groups on the basis of the classification of JNC VII, 2003 given for systolic pressure before and after the dietary intervention and presented in Table 1.

Table 1: Distribution of hypertensive subjects according to systolic pressure classification (JNC VII, 2003)

Classification	Systolic Pressure (mm Hg)	Control group (n=15)		Placebo group (n=15)		Experimental group (n=15)	
		Before n (%)	After n (%)	Before n (%)	After n (%)	Before n (%)	After n (%)
Normal	≤ 120	6 (40)	2 (13.33)	6(40)	5(33.33)	2(13.33)	5(33.33)
Pre hypertension	120-139	8(53.33)		4(26.66)	2(13.33)	5(33.33)	7(46.66)
Stage – I			5(33.33)				
hypertension	140-159	-	7(46.66)	4(26.66)	7(46.66)	8(53.33)	3(20)
Stage – II			1(6.66)				
hypertension	160 or≥160	1(6.66)		1(6.66)	1(6.66)	-	-

Before the dietary intervention, 40 per cent, 53.33 per cent and 6.66 per cent of hypertensive subjects of control group were in normal, pre hypertension and stage-II hypertension category whereas, after the dietary intervention, they were distributed as 13.33 per cent, 33.33 per cent, 46.66 per cent and 6.66 per cent into normal, pre hypertension, stage-I hypertension and stage-II hypertension category of systolic blood pressure. So, it is clear from these data that there were shifting of hypertensive subjects from normal and pre hypertension category into stage-I hypertension category which was undesirable shifting in hypertensive subjects regarding systolic blood pressure and the condition of hypertensive subjects after the dietary intervention were deteriorating. Similarly, in case of placebo group also, the pattern of change in systolic pressure was in line with the control group, i.e. the hypertensive subjects of normal and pre hypertension category were shifted into stage-I hypertension category. Once again negative shifting occurred in systolic pressure of hypertensive subjects belonging to placebo group and the net changes were undesirable.

In case of experimental group, before the dietary intervention, there were 13.33 per cent,33.33 per cent and 53.33 per cent of hypertensive subjects were in normal, pre hypertension and stage-I hypertension and after the dietary intervention there were 33.33 per cent,46.66 per cent and 20 per cent of hypertensive subjects were in the same category. So, it is clear that hypertensive subjects were shifted from stage-I hypertension into normal and pre hypertension category, which was desirable changes in systolic pressure from health point of view. By comparing the pattern of shifting of hypertensive subjects in all the three groups, the shifting was negative and undesirable in control and placebo group whereas in experimental group the shifting of hypertensive subjects was positive and desirable.

Distribution of Hypertensive Subjects According to Diastolic Pressure Classification (JNC VII, 2003):

Hypertensive subjects were distributed into four groups on the basis of classification of JNC VII, 2003 given for diastolic pressure before and after the dietary intervention and all information is given in Table 2.

Table 2: Distribution of hypertensive subjects according to diastolic pressure classification (JNC VII, 2003)

Classification	Diastolic Pressure (mm Hg)	Control group (n=15)		Placebo group (n=15)		Experimental group (n=15)	
		Before n (%)	After n (%)	Before n (%)	After n (%)	Before n (%)	After n (%)
Normal	≤ 80	10(66.66)	9(60)	6(40)	4(26.66)	2(13.33)	10(66.66)
Pre hypertension Stage – I	80-89	3(20)	3(20)	4(26.66)	6(40)	9(60)	4(26.66)
hypertensionStage – II	90-99	2(13.33)	3(20)	5(33.33)	5(33.33)	4(26.66)	1(6.66)
hypertension	100 or ≥100	-	-	-	-	-	-

Before the dietary intervention, there were 66.66 per cent, 20 per cent and 13.33 per cent of hypertensive subjects belonging to control group in normal, pre hypertension and stage-I hypertension whereas after the dietary intervention there were 60 per cent of hypertensive subjects were in normal and 20 per cent of hypertensive subjects in each pre hypertension and stage-I hypertension category. So, it is clear from these data hypertensive subjects from normal category were shifted to stage-I hypertension category which was undesirable shifting in diastolic blood pressure from health point of view. In placebo group, from the data given in Table 2, it is clear that few hypertensive subjects were shifted from normal to pre hypertension category which is again undesirable shifting like control group.

In case of experimental group, there were 13.33 per cent, 60 per cent and 26.66 per cent in normal, pre hypertension and stage-I hypertension category. But, after the dietary intervention, there were 66.66 per cent, 26.66 per cent and 16.66 per cent of hypertensive subjects in the normal, pre hypertension and stage-I hypertension category. These data clearly shown that few hypertensive subjects were shifted from stage-I hypertension and pre hypertension into normal and pre hypertension category simultaneously there were reduction in per cent of hypertensive subjects in stage-I hypertension category. All these findings clearly shown that the shifting of hypertensive subjects in different category after the dietary intervention was positive and desirable change in case of experimental group, whereas in case of hypertensive subjects belonging to control and placebo group, the pattern of shifting after the dietary intervention were undesirable.

Buckwheat based mix were given only to the hypertensive subjects of experimental group, in which positive and healthy change occurred in both systolic and diastolic pressure. On the basis of this findings it can be said that the change in blood pressure was the impact of regular consumption of buckwheat for 90 days because rest other factors like their diet, life style and medicine use were similar in all hypertensive subjects of the three groups. ie. control, placebo and experimental group. In this study, therefore, the decline in blood pressure may be due to buckwheat flour consumption. The result is also supported by the finding of Jiang *et al.*, (1995) [11]. In that study, an experiment was conducted at China on 850 people to see the role of oats and buckwheat in the treatment of both hypertension and hyper-cholesterolemia. Blood pressure was measured on 3 consecutive days. The finding of the study suggested a role for buckwheat consumption in prevention and treatment of hypertension (Jiang *et al.*, 1995) [11]. Buckwheat flour contain rutin which is a bioflavonoids found only this pseudo cereal. Rutin present in buckwheat seeds and sprouts is a flavonol and is able to antagonize the capillary fragility in hemorrhagic disease or hypertension in man (Griffith *et al.*, 1994 and Schilcher *et al.*, 1990 and Kreft *et al.*, 1999) [6, 12]. It prevents weakening of capillaries. It is useful in a variety of hemorrhagic condition e.g. bleeding from the kidney. It also helps people with high cholesterol, high BP and celiac disease (Farooqui and Sreeramu, 2004, and Gupta *et al.*, 2004) [3, 4].

Impact Assessment of Dietary Intervention on Systolic Pressure of Hypertensive Subjects: The study subjects of the control, placebo and experimental group were checked for their systolic and diastolic blood pressure before the start of intervention and after the culmination of the intervention which was for 90 days and data is given in Table 3.

Table 3: Impact assessment of dietary intervention on blood pressure of hypertensive subjects

Groups	Systolic pressure			Diastolic pressure		
	Before	After	t value	Before	After	t value
Control group (n=15)	123.73 ± 15.01	136.20 ± 19.99	4.35	74.46 ± 11.84	77.33 ± 11.02	1.2
Placebo group (n=15)	130 ± 18.50	135.6 ± 18.51	2.37	81.53 ± 10.80	84.93 ± 8.03	2.25
Experimental group (n=15)	137 ±13.87	127.73 ± 13.46	3.63*	85.4 ±6.67	79.02 ± 7.06	2.32*

Note *Significant change at 5 per cent level

Systolic pressure is the first component of the blood pressure. From the data given in Table 3, it is clear that the change in systolic pressure of hypertensive subjects belonging to control and placebo group were increasing whereas belonging to experimental group were decreasing. The per cent change in systolic pressure of the hypertensive subjects after the dietary intervention were 10.07 (+), 4.30 (+) and 6.76 (-) in control, placebo and experimental group respectively. The change in systolic pressure of hypertensive subjects after the dietary intervention were statistically non-significant in case of control and placebo group whereas in case of experimental group the change was statistically significant ($p<0.05$)which was the impact of buckwheat based dietary intervention on the systolic pressure of hypertensive subjects.

Impact Assessment of Dietary Intervention on Diastolic Pressure of Hypertensive Subjects

Diastolic pressure is the second component of the blood pressure. Similar as in the case of systolic pressure, the diastolic pressure of hypertensive subjects belonging to control and placebo group were increased after the dietary intervention but the diastolic pressure of hypertensive subjects belonging to experimental group was decreased. The per cent change in diastolic pressure after the dietary intervention were 3.85(+), 4.17(+) and 7.47(-) in control, placebo and experimental group respectively. The change in diastolic pressure before and after the dietary intervention in experimental group was found statistically significant ($p<0.05$) whereas in case of control and placebo group, the variation in diastolic pressure was not statistically significant. Looking at the data, it was observed that in case of control

group and placebo group, the hypertensive subjects had shown increase in their systolic pressure. The trend for diastolic pressure in control as well as placebo group was similar. The experimental group had shown deviation from the trend of control and placebo group. It had shown decrease in systolic and diastolic pressure in the hypertensive subjects of experimental groups.

As a general trend, during winter month in India, food becomes rich, apparently that has been observed through slight increase of blood pressure in control and placebo group. However, in experimental group, a decrease in systolic and diastolic blood pressure may be attributed to the consumption of 50 gm of buckwheat flour for 90 days continuously. Though, the difference is significant in both systolic and diastolic pressure, the trend is definitely encouraging. It is clear that the change in systolic and diastolic pressure of hypertensive subjects belonged to experimental group was the impact of buckwheat based dietary intervention on blood pressure of hypertensive subjects. So, it can be said that lowering of blood pressure after the dietary intervention in experimental group was the impact of buckwheat based dietary supplementation. The result was in accordance with the finding of Jiang *et al.*, (1995) [11]. As per the study of Jiang *et al.*, (1995) [11] that the detectable rates of high blood pressure and diabetes were 1.6 and 1.88 per cent in buckwheat eating areas compared with 7.33 per cent and 3.84 per cent in the regions without the buckwheat eating habit respectively (http://:english.peopledaily.com.cn. 2003). In another soy based dietary intervention study conducted by Jenkins *et al.*, (2002) [10] found that the effects of high and low isoflavones soy foods on blood pressure in hyperlipidemic men and women. No significant sex differences were observed, except for systolic blood pressure, which in men was significantly lower after the soy diets than after the control diet. The specific components and mechanisms responsible for this effect have not been fully established, although several theories have been examined (Potter, 1995) [13]. Investigators initially focused on the amino-acid composition of soy protein (Anthony *et al.*, 1996) [1]. Buckwheat (*Fagopyrum esculentum*) is an important medicinal plant, commercially grown for rutin and chemically, rutin is a flavonoid (Farooqui and Sreeramu, 2004) [3]. Rutin is a flavonoid which had important role in reducing hypertension by reducing systolic and diastolic pressure among human being (Jiang *et al.*, 1995 and Kreft *et al.*, 1999) [11, 12]. Buckwheat prevents high blood pressure

Conclusion

Hypertension is the most widely prevalent non-communicable disease in India, that's why it has necessitated the need of various functional foods to combat it. The result of the present study established a strong positive role of buckwheat in lowering blood pressure in hypertension. So buckwheat is an excellent example of emerging functional food. Therefore, it can be concluded that the buckwheat based functional foods can be successfully used to ensure health security of hypertensive subjects.

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