

Buckwheat Allergy and Reports on Asthma and Atopic Disorders in Taiyuan City, Northern China

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Buckwheat is an important crop in some regions of the world, with a protein content higher than in rice, wheat and sorghum.^{1,2} It is mainly grown in Asian countries like China, Korea, Tibet, Nepal and Bhutan, but also in Russia, Slovenia, Italy, Canada and the USA.³ There is a growing interest in buckwheat as a health promoting food (functional food). It was reported that buckwheat tea has preventive action on leg oedema,⁴ and that buckwheat food can reduce high blood pressure, serum cholesterol⁵ and possibly contribute to a low occurrence of cardiovascular disease in an ethnic minority in China.⁶ Since buckwheat can be used to produce a gluten free flour, it is consumed by many subjects with gluten sensitive enteropathy (celiac disease).⁷

There are two different buckwheat species grown commercially. Common buckwheat (*Fagopyrum esculentum*) is most widely grown, and allergy to this type of buckwheat has been previously

SUMMARY Allergy to common buckwheat (*Fagopyrum esculentum*) has been reported from Europe and Japan, and a 24 kDa globulin protein has been identified as one of the major allergens. In China also another type, tartary buckwheat (*Fagopyrum tartaricum*) is grown and consumed. Three groups of individuals in Shanxi province, China, were investigated for buckwheat allergy using skin prick test. The groups were: agricultural researchers with occupational exposure to buckwheat (N = 16); workers in a food industry producing buckwheat noodles (N = 25), and patients with diabetes or cardiovascular disease consuming buckwheat as functional food (N = 20). Information on atopic disorders and adverse food reactions were collected by a doctors-administered questionnaire. One male industrial worker had a positive skin prick test to buckwheat, but no symptoms while eating or handling buckwheat products. In total, 34% consumed buckwheat food at least every week, and 23% had a weekly consumption of tartary buckwheat. The prevalence of doctor's diagnosed asthma was low (1.6%). Four subjects (6.6%) reported a history of allergic rhinitis, with allergy to cedar pollen, carnation and peach.

reported.⁸⁻¹⁷ Different allergenic proteins, with IgE binding capacity in sensitized subjects, has been identified in common buckwheat with a molecular weight of 8-9 kDa, 22-24 kDa, 34-38 kDa and 69-70 kDa.^{17, 18, 19} It is believed that the 24 kDa protein is the major allergen.¹⁹

Tartary buckwheat (*Fagopyrum tartaricum*) is mainly grown and consumed in China, and a 24 kDa protein has been identified also in this type of buckwheat.²⁰ There are some publications available on

food allergy in China.²¹⁻²³ but none of these has described buckwheat allergy.

Allergy to buckwheat was reported for the first time in the scientific literature by Smith⁸ in

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1909. It is an IgE mediated immediate type reaction, similar to soybean and peanut allergy. The most common symptom is an asthmatic attack in relation to buckwheat exposure. In a Japanese study by Nakamura *et al.*,⁹ 139 out of 169 cases (82%) suffered from buckwheat asthma. Less common were nasal symptoms (23%), eye symptoms (13%), urticaria (45%), and gastrointestinal symptoms (33%). There is scarce information about occupational allergy to common buckwheat, and no studies available on occupational allergy to tartary buckwheat. In 1983, we published a study on 28 persons in a Swedish company importing and packing common buckwheat.¹⁰ Thirteen workers experienced reactions to buckwheat at work, including rhinitis, asthma, skin itching and conjunctivitis. The reactions usually came within one hour after exposure. Positive allergy tests (prick test or RAST) were detected in seven (28%) of 25 tested subjects. In a case report, occupational asthma was described in a noodle maker using buckwheat flour. A challenge test was performed, and showed an immediate strong bronchial obstruction after airway exposure to small quantities (10 µg) of buckwheat.¹⁴

The main aim of the present study was to investigate buckwheat sensitization in three groups of subjects in the Shanxi province in China. They had either occupational exposure to buckwheat, or a high food consumption of both tartary and common buckwheat. In addition, reports on other allergies and asthma was collected by a doctor's administered questionnaire.

MATERIALS AND METHODS

Subjects

The study was performed

in the city of Taiyuan, the main city (2.2 million inhabitants) in Shanxi province, west of Beijing. The area is a center for coal mining in China, but has also a tradition of growing and consuming both tartary and common buckwheat. Three groups of individuals which exposed to both types of buckwheat were selected for the study. The first group consisted of 18 researchers in agriculture, botany and biochemistry handling buckwheat in their work, 16 participated (90%). The second group consisted of 25 workers in a food factory in Taiyuan, producing buckwheat food, including buckwheat noodles, all participated (100%). The third group consisted of patients belonging to a patient society for people with diabetes or cardiovascular diseases. They consumed buckwheat food regularly as recommended by their doctors, to alleviate their disease. Twenty-six patients were invited, 20 participated (77%).

Questionnaire

A standardized questionnaire translated to Chinese (Mandarin) was answered by the participants before the skin prick test. Information was gathered on occupation, age, gender, smoking, atopic diseases, asthma, allergic rhinitis, food intolerance of different type, and medical symptoms in relation to common and tartary buckwheat, respectively. In addition, information was gathered on the frequency of consumption of buckwheat food, and frequency of occupational contact to buckwheat products. Buckwheat consumption, as well as occupational exposure to the two types of buckwheat, was described as "never", "a few times a year", "every month" and "every week".

Skin prick test

Skin prick tests were per-

formed by a standardized allergen extract from common buckwheat manufactured by ALK laboratories Inc. (Solu-Prick ALK Laboratories, California), on the volar aspect of the forearm, using a lancet from ALK. Histamine was used as a positive control. Sensitization to buckwheat was indicated by a positive skin prick test, defined as a mean wheal diameter of ≥ 3 mm. A negative control with normal saline was used, and its diameter was subtracted from the diameter of the allergen solution. The ALK-extract prepared from common buckwheat was used since there are no commercially available allergen test extract prepared from tartary buckwheat. Gel electrophoresis of the ALK-extract, an extract prepared by us from common buckwheat, and an extract from tartary buckwheat grown in China confirmed that all extracts contained a similar 24 kDa protein.²⁰

RESULTS

The mean age was 41 years (S.D. = 9) in the researchers, 34 years (S.D. = 11) in the food factory workers, 60 years (S.D. = 12) in the patient group, and 45 years (S.D. = 15) in the total of 61 participants. The mean proportion of females was 44%, with a majority of males in researchers and patients, and a majority of females in factory workers (Table 1). Consumption of both tartary and common buckwheat food products was common; 34% of all participants consumption any type of buckwheat at least once a week, and 45% consumed buckwheat at least once a month. The consumption of both types of buckwheat was common (Table 2). Occupational exposure to buckwheat, in researchers and food factory workers (N = 41), was a mixed exposure to both tartary and com-

Table 1 Demographic and medical data for the three studied groups exposed to buckwheat, and the total material

	Researchers (N = 16) %	Workers (N = 25) %	Patients (N = 20) %	Total (N = 61) %
Female	25	60	40	44
Current smoker	50	8	15	21
Doctor's diagnosed asthma	0	4.0	0	1.6
A history of atopy	19	13	15	15
Allergic rhinitis	6.3	13	0	6.8
Childhood eczema	13	0	15	8.5
Buckwheat allergy ^a	0	4.2	0	1.6

^aA positive skin prick test to buckwheat allergenic extract, and a negative test to normal saline

mon buckwheat (Table 3); 45% had a weekly exposure to buckwheat of any type, and 58% had occupational exposure to buckwheat at least once a month. The mean occupational exposure time to buckwheat was 10 years (S.D. = 7) for researchers, and 5 years (S.D. = 9) for factory workers.

Adverse reactions to buckwheat

One person had a positive skin prick test to buckwheat extract (Table 1), with a mean diameter of 5 mm for the buckwheat extract, 9 mm for histamine, and 0 mm for normal saline. He was a 50 years old industrial worker in the packaging plant, but not directly handling buckwheat products. He was a smoker, without asthma or a history of atopy. He consumed common buckwheat each month and tartary buckwheat every week. He had no symptoms while or after eating buckwheat products, and experienced no symptoms in relation to occupational exposure to buckwheat. Another worker, a 43 years old female office worker at the food factory, had slight and similar reaction (2 mm mean diameter) to both normal saline solution

Table 2 Reported food consumption of tartary and common buckwheat, in the total material of 61 participants

Frequency of consumption	Tartary buckwheat %	Common buckwheat %
Every week	23	16
Every month	23	24
Every year	45	50
Never	9	10

Five subjects did not answer the question on consumption of tartary buckwheat, three subjects did not answer the question on common buckwheat

Table 3 Occupational exposure to tartary and common buckwheat among researchers and factory workers (N = 41)

Frequency of exposure	Tartary buckwheat %	Common buckwheat %
Every week	44	32
Every month	12	6
Every year	22	32
Never	22	30

and the buckwheat allergenic extract, and a 9 mm diameter reaction to histamine. The reaction was classified as dermographism. She ex-

perienced no adverse reactions when eating tartary or common buckwheat food, which she consumed a few times a year.

Two subjects with a negative skin prick test to buckwheat and normal saline (0 mm mean diameter), and a 6 and 8 mm diameter reaction to histamine, reported adverse reactions when consuming both types of buckwheat. One was a 39 years old male researcher experienced stomach pain when eating buckwheat. He was a smoker, without a history of atopy or asthma, and consumed buckwheat a few times a year. He has been working as buckwheat researcher for the last 15 years, handling buckwheat at work every week. The other was a 38 years old non-smoking male in the patient group, who got urticaria when eating buckwheat, which he consumed a few times a year. He had a history of childhood eczema, but no history of asthma or allergic rhinitis.

Reports on other types of respiratory allergy or food intolerance

In total, 4 subjects (6.6%) reported allergy to pollen, with allergic rhinitis, none reported allergy to furry animals, five subjects (4.9%) reported a history of childhood eczema, and one reported doctor's diagnosed asthma (1.6%) (Table 1). The 43 years old female factory worker, with physician's diagnosed asthma was treated with asthma medicine. She had a history of atopy, reporting allergic reactions, including rhinitis to pollen from cedar, carnation, and peach. Two other non-smoking female workers, 29 and 32 years old, also reported tree pollen allergy. Finally, one 44 years old female researcher had a history of allergic rhinitis, reporting allergy to carnation and peach. She was a non-smoker with no other allergic problems. One subject reported food intolerance, with stomach pain while eating mutton. He was a 36 years

old male researcher, a smoker with a history of allergic rhinitis. He had no adverse reactions when eating buckwheat food.

DISCUSSION

Consumption and occupational exposure to both common and tartary buckwheat was common. In contrast, the occurrence of buckwheat sensitisation, as measured by a commercially available extract from common buckwheat, was found to be low. Nobody in the occupationally exposed groups reported any work-related reaction to buckwheat, either common buckwheat or tartary buckwheat. Two got adverse reactions at consumption of buckwheat of both types, stomach pain and urticaria, respectively, but were skin prick test negative. One factory worker with positive skin prick test to buckwheat reported no adverse reactions related to consumption or handling of buckwheat, but will be followed to see if he will develop symptoms. There is no information in the literature on cross-reactivity between allergens from common buckwheat and tartary buckwheat, or information on the complete amino acid sequences of buckwheat allergens. Comparative gel electrophoresis, however, suggested that both the ALK-extract and tartary buckwheat grown in China contained the 24 kDa protein reported to be the main allergen in common buckwheat.²⁰

There are many case reports on buckwheat allergy,^{2,8-17} but little information on the prevalence of buckwheat in the general population, or in occupationally exposed groups. From Japan, it was reported that 140 boys and 54 girls from a total sample of 90,000 schoolchildren (0.22% altogether) had IgE mediated sensitization to buck-

wheat. Most common reactions were urticaria, skin itching, and wheezing. Four out of 90,000 children got anaphylactic shocks due to buckwheat allergy, needing emergency treating.²⁴ Thus, a recommendation in Japan is to withdraw buckwheat from school lunches and picnic meals. In our previous study in Swedish food packing workers (N = 28), a high proportion (28%) had a positive allergy test to buckwheat, and 46% had any type of symptoms in relation to handling of buckwheat grains or flour.¹⁰

In total, three subjects (4.9%) reported any type of food intolerance. One got urticaria when eating both types of buckwheat, one got stomach pain from buckwheat of both types, and the third subject got stomach pain when eating mutton. In a subsequent study from a population sample of 6,563 Chinese people, the prevalence of food allergy was 3.41%.²¹ In another study in 10,144 subjects from the Sheng-Li Oil fields in Manchuria, in northern China, a similar figure of self-reported food allergy (4.98%) was found.²² In one case study from Beijing, intracutaneous skin tests were performed in 40 cases of subjects with recurrent attacks of asthma after ingestion of food. The most common positive skin tests were seen for sesame seed, peanut, cow's milk, soybean, and egg. There were also positive skin reactions to peach and mutton, but no allergy to buckwheat was reported.²³ For comparison, in a Swedish study in a random sample of 2,239 school teachers, and 2,410 school pupils, 11% of school personnel and 8% of pupils (7-17 years) reported any type of food intolerance. None of these Swedish subjects reported food intolerance to buckwheat or buckwheat products.²⁵ Adverse reactions to food

need not be allergy, but may depend on other mechanisms as well as pharmacological, toxic or metabolic mechanisms.²⁶ This position paper reports that American studies suggest that the prevalence of food allergy is about 10% in the general population (13% in children and 7% in adults), but European studies suggest a prevalence of 0.3-7.5% of food allergy in children and 2% in adults.²⁶

In total, 6.6% reported allergy to cedar pollen, carnation, and peach with allergic rhinitis. None reported allergy to furry animals, and 1.6% had doctor's diagnosed asthma. Allergy to cedar pollen is a well recognized problem in Japan.²⁷ Positive skin prick tests to carnation (*Dianthus caryophyllus*), and positive nasal provocation tests with carnation extracts, has recently been described in employees working with indoor cultivation of carnation.²⁸ Peach allergy has also been described to be more common in those with pollen allergy.²⁹ The highest prevalence of asthma and allergic rhinitis was found in the factory workers, 4.0% and 12%, respectively. These are lower figures than the prevalence of asthma and atopy reported from subsequent large studies from Western countries, performed within the worldwide European Community Respiratory Health Survey,^{30,31} but similar as some other studies from Chinese population. In the study from the Sheng-Li Oil fields in Manchuria, in northern China, the prevalence was 6.32% for allergic rhinitis and 3.84% for asthma.²²

There are indications that asthma and atopic disease has increased in the world, and interesting differences exist, even within Asia. In Singapore, prevalence of physician's diagnosed asthma was

studied in adults from three ethnical groups. In Indians, the prevalence of asthma was 6.6% and 15.2% had atopy. In Malays, 6.0% had asthma and 11% had atopy. In the Chinese population, 3.0% had asthma and 15.4% had atopy.³² Leung *et al.*³³ has studied the prevalence of atopy in schoolchildren, with questionnaires and skin prick tests. The study was performed in three cities (Hong Kong, Malaysia and in Guangzhou in southern China). The prevalence of rhinitis was 30% in Hong Kong, 18.3% in Malaysia, and 3.7% in Southern China. Corresponding figures for eczema was 20%, 7.6% and 7.2%. In another study in schoolchildren from Guangzhou in southern China,³⁴ it was shown that asthma was present in 2.4%, and atopy in 34.1%. Finally, in one study in 1,237 office workers in Taipei area in Taiwan, 29.3% of males and 28.6% of females had allergic rhinitis, and 1.5% of males and 1.1% of females had asthma.³⁵

One limitation of our study is that information on atopic disorders was based only on anamnestic information, without allergy testing to common allergens. Self-reported atopy has been validated against allergy testing in European studies. When making a comparison between self-reported hay fever and positive prick test to pollen extracts in a male worker population, a high specificity (90%), but lower sensitivity (52%) was obtained, using a positive skin prick tests against tree or grass pollen as gold standard.³⁶ In a study in Dutch women, where atopy was defined as positive test for IgE against one common allergen (house dust mite, cat, dog, birch and grass), the specificity of self-reported atopy was high (89%), but sensitivity was lower (55%).³⁷ Finally, atopic family his-

tory collected by a questionnaire to parents, using the Phadiatope IgE-antibody screening test as gold standard, was used to measure atopy. Specificity of the questionnaire to reproduce Phadiatope test was 84% for mothers and 88% for fathers. Sensitivity to reproduce Phadiatope test was 64% for mothers and 58% for fathers.³⁸ Thus, self-reported pollen allergy seems to have a relatively high specificity, but the lower sensitivity could have caused some under-estimation of the true prevalence.

In conclusion, consumption and occupational exposure to both common and tartary buckwheat was common in our study from Shanxi province in northern China. The occurrence of buckwheat allergy was low, but there were indications of non-specific food intolerance to buckwheat food in some subjects. The prevalence of self-reported asthma and atopic disorders was low as compared to subsequent data from Western countries, but similar as in some other studies from Chinese population.

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