Red kidney beans — to eat or not to eat?

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The importation of dry red kidney beans (a variety of the species *Phaseolus vulgaris*) for cultivation or consumption in South Africa is prohibited because of their potential toxicity to humans. It has been established that the haemagglutinating lectins (e.g. phytohaemagglutinin (PHA)) in kidney beans are responsible for this toxicity.
Dry bean varieties available on the South African market for human consumption as well as locally produced (for this study) and imported dry red kidney beans and imported canned red kidney beans were compared. The PHA activity and the effect of heat thereon were measured, before and after overnight soaking. The PHA activity in extracts of uncooked and incompletely cooked red kidney beans was not higher than the levels measured in 50% of the other bean varieties included in the study. These findings indicate that the toxic potentials and health risks associated with red kidney beans are similar to those of other dry beans already commercially available to South Africans.

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Man's association with legumes goes back to 2000 BC when they were first cultivated in Mexico.[1] How ancient man distinguished between edible and inedible beans will forever be a mystery, but one can speculate that many people died in the course of this experimentation. When one considers that even edible legumes may provoke deleterious reactions in humans and animals if not properly prepared, the above seems all the more likely.[2]

A number of antinutrients have been discovered in dry beans, of which phytohaemagglutinin (PHA), a lectin, has been reported to be one of the most toxic.[2] Lectins are not found exclusively in legumes, but are reported to be most concentrated in them. Scientific studies of vegetable agglutinins can be found in the literature as early as 1909.[3] Since then a steady flow of scientific information on the antinutrients (toxins), edibility and preparation of legumes has been and continues to be published.[2,4-7]

The red kidney bean, a variety of the species *Phaseolus vulgaris L.*, is believed to be one of the richest sources of PHA[4] and therefore deserves special attention when prepared as a foodstuff. It has also been established that the toxic factor in kidney beans is identical to its constituent lectins and that toxicity levels can be directly related to the haemagglutination activity responsible for toxicity to humans.[5] In Europe, 90% of dry beans is processed by

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canneries, but even so, no fewer than 50 suspected incidences of red kidney bean poisoning were reported for the period 1976 - 1989 in the UK alone.[6] These cases were characterised by nausea, vomiting and diarrhoea within 1 - 7 hours of ingestion. In South Africa, 90% of the harvest is sold as dry beans and for this reason, and with good intention, more than 25 years ago the Departments of Health and Agriculture agreed in a joint decision that the importation of dry red kidney beans for human consumption or cultivation would not be allowed in South Africa. This decision was well accepted at the time but now requires re-evaluation. There is mounting pressure from South Africans to have this self-imposed ban lifted to allow them to share in the profits generated on world markets by this extremely popular variety. The relative ease with which the toxic components in 'edible' dry beans can be removed by appropriate cooking methods served as further motivation for the re-evaluation.

This investigation attempts to re-evaluate the toxicity of red kidney beans. At the request of the South African Dry Bean Board, the PHA activity as well as the heat destruction thereof in popular varieties of commercially available dry beans were examined and compared with imported and locally grown red kidney beans. An imported canned sample of red kidney beans was also tested to establish the PHA levels present in processed red kidney beans commercially available for human consumption.

Material and methods

Samples of the following 6 varieties of dry beans representing two species were received from the Dry Bean Board for a comparative study of PHA activity and heat destruction: (*i*) large white kidney beans (*Phaseolus coccineus L.*); (*ii*) brown haricot beans (*Phaseolus vulgaris*); (*iii*) small white canning beans (*Phaseolus vulgaris*); (*iv*) red speckled sugar beans (*Phaseolus vulgaris*); (*v*) local red kidney beans (*Phaseolus vulgaris*); and (*vi*) imported red kidney beans (*Phaseolus vulgaris*). A sample of imported canned red kidney beans (Furman's, Furman Foods Inc., USA) was also tested.

Thermal inactivation

Sixteen samples of whole beans (approximately 10 g each) from each variety were divided into the following four groups:

1. Four samples were soaked overnight in 50 ml phosphate-buffered saline (PBS) after which 3 samples were cooked in 50 ml PBS at 100°C for 15, 30 and 60 minutes, respectively. One uncooked sample was included to establish the initial PHA activity of each variety.
2. Four samples were treated as in (1), but without soaking.
3. Four samples were treated as in (1), but cooked at 85°C.
4. Four samples were treated as in (2), but cooked at 85°C.

Soaking and cooking of the beans were done in cellulose stoppered, 250 ml Erlenmeyer flasks in a waterbath. All the flasks were put into the preheated water simultaneously; each group was removed when the allocated time had elapsed, and placed on crushed ice for rapid cooling.

Bean extract preparation

After cooling, the contents of each flask were homogenised in a Waring blender for 30 seconds and centrifuged (40 000 x g, 30 minutes). The supernatant was pipetted into sealable plastic test tubes and frozen to be assayed the next day.

A sample of the imported, canned red kidney beans was also extracted as described above.

Preparation of red blood cell suspension

Fresh porcine whole blood (500 ml) was defibrinated by manual swirling with glass beads in an Erlenmeyer flask for 15 minutes. The red blood cells (RBCs) were then washed once with PBS and packed by centrifugation (400 x g, 2 minutes) after which their sensitivity to PHA was increased by treatment with trypsin (Type 1x, Sigma Chemical Co., St Louis, Mo., USA). Fifteen millilitres of packed RBCs were incubated at 37°C for 60 minutes in 2 ml saturated trypsin solution in 0,067M potassium phosphate buffer, pH 7,4. After treatment the cells were washed 3 times with PBS and then diluted with PBS to give a RBC suspension containing 8×10^7 cells/ml.

Agglutination assay

Purified, lyophilised PHA standard (Phytohaemagglutinin PHA-M, Sigma Chemical Co., St Louis, Missouri, USA) was dissolved and diluted in PBS to yield solutions containing 10, 5, 2,5, 1,25 and 0,625 µg PHA/ml, respectively. In 160 x 17 mm test tubes, 1 ml RBC suspension was mixed with aliquots (1 ml) of PHA-standard from each dilution, or with 0,1 ml of bean extract to construct a standard curve. One control in which either the PHA standard or the bean extract was replaced with 1 ml PBS, was added to each group. Preparations were allowed to stand for 1 hour at room temperature. The cells in the mixtures were then packed by centrifugation (400 x g, 45 seconds), resuspended by whirlymixing and allowed to stand for 15 minutes. Thereafter 0,1 ml was withdrawn from the midpoint of each sample and added to 20 ml Isoton III. The RBCs were then counted in triplicate by means of a Coulter counter model Z_F to determine the number of RBCs remaining in suspension. The mean of each triplicate determination is shown in Tables I - IV.

Results and discussion

PHA activity was calculated from the RBC count after exposure to the bean extracts and expressed as a percentage of the original cell count (Tables I - IV). No haemagglutinin was detected in the extracts prepared from the imported canned red kidney beans.

Table I shows the percentage haemagglutination from extracts prepared from unsoaked beans cooked at 100°C for 15, 30 and 60 minutes, respectively. After 60 minutes at 100°C all the varieties showed zero agglutination except local red kidney beans which retained 2% of their original PHA activity. After 30 minutes at 100°C all PHA activity in the local small white canning and the imported red kidney beans had been destroyed.

Table I. Percentage haemagglutination produced by unsoaked beans after conventional cooking at 100°C*

Variety	Heat exposure time (min)			
	0	15	30	60
Large white kidney	ND	99	98	0
Brown haricot	ND	98	12	0
Small white canning	ND	94	0	0
Red speckled sugar	ND	99	97	0
Local red kidney	ND	99	93	2
Imported red kidney	ND	96	0	0

* No haemagglutination was detected in imported canned red kidney beans.
ND = not determined.

Overnight soaking markedly reduced the cooking time at 100°C required to destroy PHA activity (Table II). Thirty minutes at 100°C were sufficient to eliminate all PHA activity in all the bean varieties after overnight soaking. Even after 15 minutes under these conditions, the local red kidney beans, the imported red kidney beans and the large white kidney beans retained only 2% of their original activity.

Table II. Percentage haemagglutination produced by beans (soaked overnight) after conventional cooking at 100°C*

Variety	Heat exposure time (min)			
	0	15	30	60
Large white kidney	99	2	0	0
Brown haricot	98	0	0	0
Small white canning	97	0	0	0
Red speckled sugar	96	0	0	0
Local red kidney	94	2	0	0
Imported red kidney	98	2	0	0

* No haemagglutination was detected in imported canned red kidney beans.

Sixty minutes' cooking time at 85°C, even with overnight soaking, was insufficient to eliminate all PHA activity in all the bean varieties except the small white canning beans (Tables III and IV).

Table III. Percentage haemagglutination produced by unsoaked beans after conventional cooking at 85°C*

Variety	Heat exposure time (min)			
	0	15	30	60
Large white kidney	ND	99	98	99
Brown haricot	ND	99	99	5
Small white canning	ND	98	95	0
Red speckled sugar	ND	98	98	95
Local red kidney	ND	99	99	98
Imported red kidney	ND	98	98	98

* No haemagglutination was detected in imported canned red kidney beans.
ND = not determined.

Table IV. Percentage haemagglutination produced by beans (soaked overnight) after conventional cooking at 85°C*

Variety	Heat exposure time (min)			
	0	15	30	60
Large white kidney	99	99	99	97
Brown haricot	95	80	32	3
Small white canning	95	97	44	0
Red speckled sugar	97	99	98	95
Local red kidney	99	99	98	97
Imported red kidney	99	98	98	65

* No haemagglutination was detected in imported canned red kidney beans.

In this study no attempt was made to determine the actual levels of PHA present in each bean variety. The percentage haemagglutination achieved with different amounts of PHA standard (Fig. 1), however, gives an indication of the levels of PHA present in the extracts under investigation.

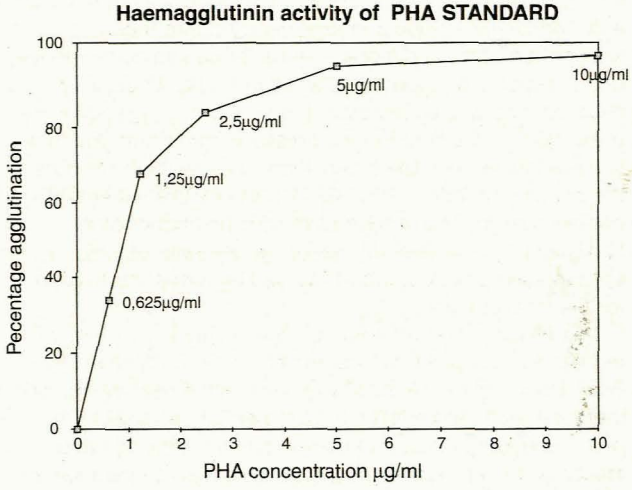

Fig. 1. Standard curve of percentage haemagglutination of porcine RBCs caused by different amounts of PHA standard.

The PHA activities recorded for uncooked and incompletely cooked local and imported red kidney bean samples subjected to identical test conditions were not higher than the levels recorded for 50% of the other bean varieties included in the study. This indicates similar toxic potentials and risk from dried beans already available to South Africans.

We believe that, as is the case with unpasteurised milk, a greater awareness of the possible dangers associated with raw and incompletely cooked dry beans on the part of producers, consumers, and the medical community could enhance the utilisation of this valuable foodstuff and should therefore be promoted.

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