Non-uniform implementation of ban on *Lathyrus* cultivation in Indian states leading to unwarranted exposure to consumers

The cultivation of *Lathyrus sativus* L., popularly known as ‘khesari’, is being continued due to its low irrigational requirement, sturdy nature and drought-resistant properties. *L. sativus* was earlier consumed as a staple food by the economically poor strata. Continued consumption in appreciable quantities was implicated to cause irreversible deformities/crippling of the lower limbs, leading to the human disease condition popularly referred to as neuroathyrosis. The causative agent was identified as an unusual non-protein free amino acid, β-N-oxalyl-L-α,β-diamino propionic acid (ODAP), also referred as β-N-oxalyl amino-L- alanine. The toxin content in lathyrus seeds has been shown to vary between 0.2 and 1.0 g per 100 g. Efforts on developing low toxin varieties are being pursued through selection and genetic engineering, but have not materialized as yet.

At present there is a ban on the cultivation and sale of lathyrus in majority of the states in India under the Prevention of Food Adulteration (PFA) Act. However, three states, namely Bihar, Madhya Pradesh (MP) and West Bengal (WB) still permit its cultivation, presumably for fodder use. It is suspected that being comparatively cheaper, lathyrus pulse may even get channelized for human consumption, especially through powdered Bengal gram flour (BGF), one of the most popular ingredients of the Indian household. The present study has hence been undertaken to evaluate the probability of unwarranted admixture of *L. sativus* in BGF among different states of India and to evaluate its health-risk consequences to unsuspecting consumers.

The states covered in the study were demarcated into four geographical zones (Figure 1). The north zone included Haryana, Himachal Pradesh (HP), Punjab, Uttar Pradesh (UP) and Uttarakhand, while Andhra Pradesh (AP), Karnataka, Kerala and Tamil Nadu (TN) constituted the south zone. The west zone comprised of Gujarat, Maharashtra, MP, Chhattisgarh and Rajasthan, whereas Assam, Bihar, Jharkhand, Orissa and WB were clubbed under east zone. Four to five cities from each state were selected and samples of loose BGF (*Cicer arietinum*) locally called ‘besan’, were picked up from the retail market outlets.

ODAP content was determined to find the *L. sativus* admixture in BGF, employing the most widely accepted method of Rao et al., as further optimized by Abegaz et al. Bengal gram flour sample (100 mg) was taken and successively extracted 5 times with 2 ml of fresh ethanol each. After centrifugation, supernatants were pooled and duplicate 100 μl of aliquots were hydrolysed with 0.3 ml of 10 N KOH for 30 min in boiling water bath. The colour was developed with freshly prepared 2 ml orthophthalaldehyde (OPT) reagent and measured at 420 nm after 15 min.

A linearity of lathyrus flour spiked in Bengal gram flour was observed in the range of 20–100 mg/g ($R^2 = 0.9963$) with a recovery of 83–93%. Results of analysis of BGF samples from the four geographical zones are shown in Table 1. Among 682 analysed samples, 256 amounting to 37.5% were found to contain lathyrus pulse admixture in BGF. There was virtually no prevalence of lathyrus in the south zone, while its presence ranged from 37.0 to 50.2% in the remaining three zones (Table 1). The proportion of *L. sativus* admixture in these zones ranged between 30.7% and 53.9%.

The results for individual states are shown in Figure 2. Maximum lathyrus substitution in BGF to the extent of 100% was seen in Punjab, followed closely by Bihar (95.5%). The magnitude of mixing was 47.9% and 41.3% in Rajasthan and MP respectively, while in Assam and WB it was 24.2% and 22.1% respectively. Both UP and Haryana showed moderate use of lathyrus to the tune of around 16%. Lathyrus mixing in BGF was occasional in Orissa and Maharashtra (11%), while there was virtually no usage of lathyrus in the south zone, i.e. in AP, Kerala, Karnataka and TN. Two other states, namely Gujarat and HP also did not show any admixture of lathyrus in BGF samples.

**Figure 1.** Map of India showing various states covered in the study clubbed under four geographical zones.
The proportion of lathyrus pulse admixture in BGF is shown in Table 2. Among 256 lathyrus-positive BGF samples, over 35% showed up to 25% lathyrus admixture, while around 48% samples contained over 25–75% admixing of lathyrus. The remaining 16% of BGF samples was found to contain more than 75–100% lathyrus substitution. Based on lathyrus-positive samples, the average and 95th percentile values of lathyrus pulse admixture in BGF works out to be 40.7% and 100% respectively (Table 2).

In India, cases of neurolathyism have been reported in the past from UP, MP, Bihar and occasionally from Orissa and WB in the economically poor strata of the population consuming large amounts of lathyrus as staple food. Reports are also available from Jammu and Kashmir, Punjab and Maharashtra. Though at present fresh full-fledged cases of lathyrisism have not been witnessed, sub-clinical patients have been occasionally seen. A recent rapid survey carried out by the National Institute of Nutrition, in the villages of Bhandara district neighbouring MP has revealed that several people were affected with toxicity-related illness on consuming L. sativus.

From the present study, it is apparent that the illicit use of L. sativus pulse continues in many states, though none of the four south zone states shows lathyris consumption. A recent study in Bangladesh has shown that besides the conventional outcome of neurolathyrisism, L. sativus intake is also responsible for the additional osteolathyrogenic symptoms observed in some neurolathyrism patients. Earlier, Cohn and Streifler had suspected osteolathyrogenic symptoms in lathyris patients who had consumed L. sativus several years back in a German forced labour camp. A number of recent studies suggest that extreme care is needed with the toxicity assessment of even low exposure of L. sativus because other pre-disposing conditions such as malnourishment, genetic pre-disposition, simultaneous metal exposure, altered blood–brain–barrier conditions, etc. could stimulate the onset of lathyris-induced toxicity. Thus, a good understanding of the likely interaction of the environmental and physiological conditions and various pre-disposing factors is needed to rule out the possible onset of latent lathyris in vulnerable populations exposed to even low amounts of this pulse. Also, the likely variations in ODAP metabolism in humans cannot be ruled out and may define the outcome of toxicity of this glutamate analogu. Hence even low-level consumption cannot be vouched safe and is best avoided.

It is apparent that the non-uniform implementation of ban on the cultivation of L. sativus under the provisions of the