
Antinutritive Factors and Plant Toxins

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TAKE A LESSON FROM THE DEER. I worked one summer in the laboratory of forage scientist Dr. VanSoest at Cornell University. He said we should learn a lesson from the deer. Deer can eat plants with no ill effect that are poisonous to cattle. The difference is that deer are browsers. They eat a small amount of one thing, then move on to many other things during the course of the day. In contrast, when a cow likes something it keeps eating. The body is capable of detoxifying small amounts of a great many things. This is sound advice to keep in mind when evaluating plant nutrition and toxicities.

I have thought of that many times since working with so many kinds of plants at ECHO. No doubt a steady diet of some would be harmful, as is the case with many common foods like cassava which contains cyanide or spinach with oxalates. There is a comforting degree of safety in "browsing" among a large selection of foods. Not only will your body more likely be able to detoxify the small amounts of any particular toxin, but it is more likely to find at least a minimal amount of the various nutrients it requires. All the more reason to work to bring diversity to the diets of people with whom we work. (https://cdn.ymaws.com/echocommunity.site-ym.com/resource/resmgr/a_to_z/azch11an.htm#Table)

A PERSPECTIVE ON NUTRITIONAL LIMITATIONS OF AMARANTH. (Excerpted from ECHO's Technical Note on amaranth.

(<https://www.echocommunity.org/resources/6719b929-1921-4850-8827-113addfdfa1d>) Based on the content of nutrients, amaranth seed and leaves are exceptionally nutritious. Amounts of vitamin C, iron, carotene, calcium, folic acid and protein are especially high in the leaves. There are reports that the incidence of blindness in children due to poor nutrition has been reduced with the use of 50 to 100 g of amaranth leaves per day. On a dry weight basis, the protein content of the leaves is about 30%. Amaranth seeds have more protein than many grains (15%) and this protein is high in the amino acid lysine that is usually low in cereals, and sulfur-containing amino acids that are usually low in legumes. Based only on an analysis of those nutrients that are present, amaranth would seem to be almost a "miracle food."

The presence of rather high amounts of oxalic acid and nitrates place some limitation on the quantity of leaves that should be consumed daily. The amount of oxalic acid is roughly the same as that found in spinach and chard. Excessive amounts (over 100 g per day?) may result in a level of oxalic acid that begins to reduce the availability of calcium in humans. This is especially a concern if calcium intake levels are low to begin with. Nitrate in vegetable portions of amaranth is a concern because it is hypothesized that nitrates may be chemically changed in our digestive tracts into poisonous nitrosamines. Evidence for this is lacking at the present time. Nevertheless, over 100 g per day may be an unsafe amount to eat according to some scientists. The levels of both oxalic acid and nitrates are reduced by boiling the leaves like a spinach, then discarding the water.

The seed should be as nutritious as cow's milk or soybeans, based only on the quality and amount of protein present. But (</resources/d419a423-a66c-42f8-a365-d690d6635512>) there are apparently some "anti-nutritional" factors in raw amaranth that lead to quite unexpected results in feeding trials. Performance is improved somewhat by cooking. For example, Dr. Peter Cheeke at the University of Oregon compared the rate of weight gain for rats on diet of corn and ground amaranth seed (*Amaranthus hypochondriacus*), either raw or cooked. The average daily gain for rats on the corn-soybean diet during the first 20 days was 3.9 grams. Rats fed the corn-amaranth diet gained on 0.3 grams per day. The average daily gain for rats fed corn and cooked amaranth was 1.6 grams. Raw amaranth seed is extremely unpalatable to rats (i.e. they will not eat it readily). This does not seem to be improved much by cooking. In another study, Dr. Cheeke found that after 11 days on corn-amaranth diet, rats "had an unthrifty, hunched-up appearance, and exhibited symptoms typical of semi-starvation."



I phoned Dr. Cheeke to get his perspective on the seriousness of these negative results. He told me that there are definitely toxins and/or anti-nutritional factors in the raw grain and that it is less of a problem with cooked grain. He said that a scientist in Australia has been feeding raw amaranth seed to poultry as the major component of the diet. He found that chickens went into spasms, convulsions, and finally died. This unidentified factor causes liver damage. Other problems are caused by saponins, including the unpalatability. But to keep this in perspective, Dr. Cheeke pointed out that there are few raw foodstuffs which do not have problems. Raw soybeans contain

10 kinds of toxins. Raw kidney beans will kill rats, but the problem is eliminated by cooking. The key seems to be to use the seed in moderate amounts and to cook it. I asked whether I could say that unless people had little other than amaranth to eat, there should be no problem. He thought that this was probably a fair statement. It is our opinion that more research needs to be done before we can recommend amaranth grain as a major ingredient in animal feed. To our knowledge it has not been shown whether these factors decrease the value of amaranth in human nutrition. It is quite possible that some varieties may lack these anti-nutritional factors. Until more work is done, however, the feeding trial results must moderate our otherwise enthusiastic promotion of amaranth grain. But remember, the Aztecs did quite well on at least selected varieties!

(https://cdn.ymaws.com/echocommunity.site-ym.com/resource/resmgr/a_to_z/azch11an.htm#Table)

TOXIC PLANTS CONSUMED BY GOATS MAY AFFECT HUMANS WHO DRINK THEIR MILK. A reader sent us an interesting news note from the August 1983 issue of *Popular Science*. Dr. Donald Crosby at the University of California at Davis reported that a woman from a backwoods area had a deformed baby. Dr. Crosby noted a striking resemblance to the deformed limbs of calves born to cows that forage such toxic plants as lupines. Throughout her pregnancy, the woman had drunk milk from a goat that had foraged freely in an area where lupines are abundant. Dr. Crosby then fed lupine seeds to a goat and found dangerous levels of the toxins in the milk four hours later. The goat in question had also given birth to deformed offspring. The evidence is circumstantial, but persuasive. It is something you should keep in mind. (https://cdn.ymaws.com/echocommunity.site-ym.com/resource/resmgr/a_to_z/azch11an.htm#Table)

CAN PEACH PITS BE USED AS FOOD? Dennis Zehr wrote from Lesotho that they are blessed with an abundance of peach trees. The children eat the pits in limited quantity and they have been fed in limited amounts to chickens. He asked about their safety.

We passed the question on to Dr. Julia Morton. "As with certain varieties of lima bean and cassava, kernels of the peach, bitter almond, chokecherry, apricot and apple contain cyanogenic glycosides which, under certain conditions, release hydrogen cyanide gas. Some have caused human and animal fatalities when consumed in quantity. Pre-soaking and thorough cooking may render them safe for animal feed. But marketing would be a hazard as one would have no control of the manner in which they would be used. Peach kernels have been employed in homicide." It does not sound like it is worth the risk. (https://cdn.ymaws.com/echocommunity.site-ym.com/resource/resmgr/a_to_z/azch11an.htm#Table)

DO NOT EAT SPROUTED SORGHUM. You have heard of the added nutritional benefits that can come from sprouting seeds before eating them. Grain sorghum is an example of how it is not safe to assume that any edible seed can be eaten after sprouting. According to an article in *Science News*, this practice used to be recommended to improve the nutritional value of sorghum. The sprouts were eaten fresh or dried and ground into a meal. "The average fatal dose of HCN (cyanide) is 50 to 60 mg, and this amount was readily obtained from sprouts grown from 100 grams of sorghum seed. Consumption in a (/resources/9b596db9-2a2a-478c-81a1-0326df04e334)single meal of sorghum sprouts or the dried product derived from 100 g of seed is entirely possible." Dried sprouts retained the high levels of cyanide. The authors say this presents a special risk to people with chronic cyanide poisoning from diets high in cassava and sorghum grain. Sprouting could increase the already serious levels of cyanide in their diets by as much as 500 to 1000 fold. We now have the original research article and will share it with you if this is a matter of special concern. (https://cdn.ymaws.com/echocommunity.site-ym.com/resource/resmgr/a_to_z/azch11an.htm#Table)

IS VELVET BEAN SAFE TO EAT?

(<https://www.echocommunity.org/resources/300bccb6-5f2e-42e7-94cb-9cbb19b6de53>) [NOTE: Read the following articles to see the development of

research's answer and current perspective on this question.] Velvet bean is generating so much interest and the pressure to use it for human food is considerable. The multiple uses of velvet bean (*Mucuna* spp.) as a green manure plant, for weed and erosion control and for moisture conservation has been discussed (see chapter on Soil Health). Its use in Central America is increasing rapidly. It is among the most



frequently requested seed in ECHO's seedbank and others are starting to get excited too. For example, Felix Quero in the Philippines says, "What impresses us most is its aggressiveness. It could even compete with the problem grass *Imperata cylindrica* and has potential of at the same time controlling this grass and providing food."

Yet its safety as a human food is questionable. The book *Food Legumes* says the plants are mainly used for grazing although mature seeds are also fed to animals. "They are used mainly for feeding cattle or sheep [i.e. ruminants] and can only be fed to pigs if they constitute less than 25% of the diet. They are considered unsuitable for poultry." [This may not be as bad as it sounds if, as I presume, they are speaking of raw beans. You cannot feed very much raw soybean either and a raw kidney bean diet will kill rats.] "Velvet beans can be used as a human food but require considerable care in their preparation... In many parts of Africa and Asia they are regarded as a famine food. The toxic principle can be removed by boiling and soaking the seeds in several changes of water."

Their safety is a very important question. The vines produce beans abundantly. It would be a terrible waste to not use such a nutritious bean [28-32% protein] for human food unless it is indeed dangerous. For example, when I visited the World Neighbors project in Honduras last December a drought had destroyed the regular bean crop. Yet there was a heavy yield of velvet beans. Because velvet beans were all they had, I understand that the people were eating and enjoying them regularly. They boiled them with corn, removed the seed coats by hand, then ground equal amounts of beans and corn to make tortillas. I also enjoyed refried velvet beans there.

Roland Bunch reports that velvet bean coffee is becoming popular in their project area, where it is sold as "nutricafe." Daniel Salcedo's organization Pueblo to People wanted to market nutricafe in the States to provide income to small farmers in Honduras. He mentions that older people who have had trouble with coffee because it is diuretic (increases urination) love nutricafe, which does not have this effect. (The "nutri" part of the name is probably misleading. Daniel told me he had brewed nutricafe tested for protein and found little.) But if the toxic material is removed by boiling the beans and discarding the water, might this be a dangerous drink? Or does roasting the beans or the boiling process itself render it harmless?

TOXICITY. The instruction to "boil in several changes of water" does not provide **perspective**. The same warning could mean that velvet beans that are not so prepared could prove fatal with a single meal or that they would cause some slight symptom if consumed regularly for a year--or any degree in between.

The most likely toxic principle is L-dopa. Velvet beans contain so much L-dopa (6-9% of the dry weight of seeds with seed coats removed) that they are the primary natural source of this compound. It is one of the most effective drugs against Parkinson's disease. Neurophysiologist Dr. Judy Toronchuk tells us that L-dopa causes neurological symptoms. These can include hyperactivity, muscle spasms, cardiac irritability, hypotension and vasoconstriction. But it causes nausea at much lower doses. "So probably if people were to ingest the un-degraded L-dopa they would voluntarily stop eating it, due to nausea, before they had eaten enough to affect the brain."

Judy checked with a pharmacology professor. He felt that the L-dopa would break down sufficiently with cooking, particularly if cooked in water. It breaks down readily in the presence of moisture and forms the harmless pigment melanin. In fact the drug must be stored in dry, brown bottles which must not be allowed to exceed room temperature. (Might beans that have been stored for a year in the hot, humid tropics have less L-dopa than freshly harvested beans?)

There is also an unusual compound (a cyclic imino acid) that presumably is a natural derivative of L-dopa. The articles I reviewed mentioned no biological effect of this compound.

RESEARCH. This brings us to an aspect of ECHO's ministry that is not normally visible to our network. Many undergraduate programs require research as part of the science major. ECHO encourages such students and their professors to undertake projects that would benefit small farmers in the third world. One of the projects we suggested in our "Research Opportunities" write-up was to look into this question of safety of velvet bean. Senior premedical major Sarah Kramer and her advisor Dr. Bob Kistler at Bethel College in Minnesota did just that, and came up with some very interesting information.

First, a computerized literature search turned up two journal article reports of people eating velvet beans. One study mentioned that they found a village in Ghana where some people ate velvet bean daily. Another study found that rural people in southern Nigeria use it as a soup thickener by first boiling to remove the hard seed coat, then grinding it.

Tom Post in Belize forwarded us a report like none other I have encountered from the book *Poisonous Plants of the United States and Canada* by J. M. Kingsbury. Using the velvet bean grown in Florida years ago "even boiled for an extended time, the beans were unpalatable and produced, an hour or more after ingestion, symptoms of nausea and discomfort. While cooking, the beans gave off a volatile substance which produced a smarting sensation in the eyes and a pronounced headache among those experimenting with them." This is so unlike recent reports where the tropical velvet bean is being used that there must be considerable differences in toxicity between varieties. ECHO distributes two varieties of velvet beans. One is the kind that has no itch-producing fuzz on the pods and produces seed only during short days. We call it our "tropical velvet bean." That is the one we normally send overseas unless specified differently. Seeds may be white, mottled or colored. The other is the less vigorous kind grown in the southeastern USA which we call the 90-day velvet bean and is possibly the kind ([/resources/768ad6a5-62d4-4af6-a825-](/resources/768ad6a5-62d4-4af6-a825-866353a3a08b)



866353a3a08b) mentioned in this report. However, Sarah's experiments with mice described below were with this 90-day type and she found no such problems.

Sarah's computer search turned up a rat feeding trial in Ghana using velvet beans. Results were reported in terms of grams of weight gain per gram of protein eaten (the protein efficiency ratio or PER). Rats fed raw beans lost weight (PER -3.03). The PER for rats fed autoclaved (i.e. pressure cooked) beans was 2.31, and for rats fed only the ideal diet it was 3.41. The lower value for beans does not necessarily mean there was still some toxicity. The protein of many legumes is not always digestible, or may be lower in one of the essential amino acids than the ideal control diet. The latter appears to be the case here because rats fed autoclaved beans to which the amino acid methionine (which is often in inadequate supply in legume seeds) was added had a PER of 3.59.

A study in the States showed that the likely benefit to the plant of such a high concentration of L-dopa is protection of the seed. "Mature seeds of velvet bean are conspicuously free from attack by small mammals and insects." Small amounts of L-

dopa that they added to an insect diet produced toxic effects. Concentrations as high as found in velvet bean seeds inhibited feeding completely.

THE FEEDING EXPERIMENT. Sarah did a 27-day feeding trial with mice. She used the 90-day variety of velvet bean because we did not have enough of the tropical kind to do a feeding trial. Four mice were assigned to each of 9 experiments. The control mice were fed commercial mouse chow. When an experimental diet was used, every third day 4.0 grams of the control diet (mouse chow) was added to provide nutrients missing in the experimental diet. This amount was chosen because that was the average daily amount eaten by rats fed only the control diet. Mice fed the control diet gained 8 grams. Mice fed the control plus the amino acid methionine gained 7.5 grams, which statistically was not significantly different at the 1% confidence level.

[A note to those not familiar with statistics. In everyday English we use the word "significant" about the same as the phrase "a lot." "A Mercedes is significantly more expensive than a Volkswagon" means it costs "a lot" more. A scientist uses the word differently. If the weight of rats in two experiments is "significantly" different we mean that statistically speaking the probability is small that random chance could have accounted for the results.]

EFFECT OF "NUTRICAFFE." One set of mice was fed the control diet except that velvet bean coffee was the only thing available to drink. Beans were roasted at 300°F on a cookie sheet for one hour. To make coffee, 40 g of roasted beans were boiled in 700 ml of water for one hour. Mice gained 10.2 grams, which was not significantly different from the control.

EFFECT OF RAW VELVET BEANS. Mice fed raw beans lost 5.6 grams. With added methionine they lost 6 grams. This could be caused by the L-dopa, but so many harmful things occur in raw bean seeds that some other cause cannot be ruled out. This was significantly different from the control.

EFFECT OF BOILING THE BEANS. Beans that had been soaked with one change of water were boiled 30 minutes (40 g in 700 ml water) then another 30 minutes in fresh water. They gained 4.8 grams. Mice fed boiled beans with added methionine gained 3.8 grams. These were not significantly different from the control.

For your consideration, Doug Welch in Malawi wrote, "Velvet beans are consumed here. They were displayed at the trade fair as one of the beans produced for consumption. There is a story of how villagers fled when attacked and left some partially cooked velvet beans. The hungry raiders ate them and all died. They have to cook the beans twice."

EFFECT OF ROASTING THE BEANS. Mice fed beans roasted at 300°F on a cookie sheet for one hour gained 1.5 grams. Those fed roasted beans plus methionine gained 3.0 grams. Both were significantly less than the control but not than the cooked beans.

WHAT PERSPECTIVE CAN WE GIVE? There is not enough evidence to say with certainty that there are no problems from eating cooked velvet beans. We very much need more research, but human need does not wait for science. What should you (</resources/3d18ed95-3817-4865-aa49-1868add5ee8a>) recommend in the meantime? Considering everything that has been said above, if velvet beans were available and I was hungry or my diet was low in protein, I would definitely eat them

after thorough cooking. If I were neither hungry nor malnourished, but was living at a subsistence level, I would occasionally eat velvet beans. (I am none of the above and do not eat velvet beans except as a curiosity if they are offered.) I would definitely eat modest servings at first, and consider changing my cooking methods if nausea occurred. I would warn families of possible symptoms and ask them to report any



problems to me. I would not eat the wild velvet beans unless forced to do so and would be doubly cautious. The same would go for any new variety that I might obtain unless I knew that it was eaten elsewhere. I would feed them freely to pigs and chickens only if I had the firewood to cook them first. If at all possible I would "take a lesson from the deer" and browse small quantities of many foods, not eating too much of one thing.

New evidence has led us to offer the following guidelines at present. Has there been a failure of the bean crop in your area, but velvet beans are abundant? If so, it is almost certainly better to make use of velvet bean than to suffer hunger or protein malnutrition. Is the food situation a bit less desperate than that, but people still do not have enough to eat? If so, consider using velvet beans in moderation and not every day. Are there plenty of alternative sources of protein? If so, do not eat the velvet beans. Velvet bean coffee has a lot of dopa in it. It should not be consumed regularly. (https://cdn.ymaws.com/echocommunity.site-ym.com/resource/resmgr/a_to_z/azch11an.htm#Table)

NEW INFORMATION ON THE TOXIC SUBSTANCE IN VELVET BEANS. Velvet beans are being grown more widely, because corn yields can be increased considerably by intercropping with velvet beans. Velvet beans have potential to be a significant food. Bean yields are high, sometimes when common beans fail due to drought. The beans are nutritious, with a high protein content. Many recipes have been developed for their use and people enjoy the taste. Herein lies a major dilemma for farmers and their advisors. About 5% of the weight of the bean is a psychoactive substance called "dopa." Dopa is still a commonly prescribed treatment for Parkinson's disease, though it has side effects such as uncontrolled muscle twitches and, in extreme cases, even psychotic disorders including schizophrenia.

Dr. Rolf Myhrman brought both good and bad news on the subject at ECHO's Conference for Agricultural Missions. In his lab at Judson College in Illinois, he has been studying dopa in velvet beans from different countries and after different methods of preparation for human consumption. One thought has been that one might get rid of the dopa by removing all the seed coats. This can be easily done by hand after cooking. However, Rolf was unable to detect any dopa in the seed coats.

One major use of velvet bean by humans is to make a coffee substitute. (The coffee is called "nutri cafe" in Central America and the bean is sometimes called "Nescafe bean.") Ideally, the dopa would either be destroyed by the heat or remain in the grounds, leaving the coffee free of dopa. Rolf found, on the contrary, that making "coffee" is an ideal way to extract intact dopa! "An 8-ounce cup of velvet bean coffee can be expected to contain between 250 and 300 mg of dopa. For comparison, a physician might start a Parkinson's patient on 500-1,000 mg of dopa per day." [The other side of the question is whether someone with Parkinson's disease, but who cannot afford prescription dopa, could drink velvet bean coffee as a treatment. Do any physicians in our network have ideas on this?]

Rolf is working closely with Dr. Dan Buckles at CIMMYT, the International Center for Improvement of Corn and Wheat. According to Dr. Buckles, many people in Ghana eat velvet beans most days, using them primarily as a soup thickener. People in Benin mix 10-30% velvet bean flour with corn meal. Various preparation techniques are being used and sent to Rolf for analysis.

The good news is that a large fraction of the dopa can be removed from beans by grinding and soaking in water. Simple detoxification techniques might soon be available to remove most of the dopa. "Soaking the powder in room-temperature water, even for only two minutes, removes over half of the dopa. A second two-minute soak removed another 29%. Eighty percent is removed in two short soaking periods." Soaking 5-10 minutes does not remove additional dopa.

Using 50 deg.C water is no more effective than water at room temperature. However, soaking 5 minutes in boiling water removed 89% of the dopa and repeating the soak removed 99%.

Dr. Buckles sent Rolf velvet beans from a community in Ghana where people regularly eat velvet beans. Might these be extra low in dopa? Surprisingly, they had even more dopa than some others. Rolf suspected that they are detoxifying the beans and requested details of food preparation methods.

"We now understand how the Ghanians remove the dopa. They boil the beans 45-60 minutes, discard the water, add cool water and let the beans cool, then discard that water. Although our extraction techniques have all been with flour, it does not surprise me that they are removing a significant amount from whole beans by boiling."

You may contact Dr. Myhrman at fax 708/695-0407 or e-mail rmyhrman@nslsilus.org. This work began when Rolf requested an ECHO publication called *Hunger-Related Research Opportunities*, which lists research projects that could be performed with a modest budget that would benefit peasant farmers. (https://cdn.ymaws.com/echocommunity.site-ym.com/resource/resmgr/a_to_z/azch11an.htm#Table)

SPANISH-ENGLISH VELVET BEAN RECIPES. Aware of all these cautions, some of you still may decide it is necessary to use velvet bean as a food source, if people are hungry or suffer from protein deficiencies and there are no other alternatives. When I visited the World Neighbors project in Honduras a few years ago they were in the midst of a drought. The crop of common beans had failed, but the velvet beans produced abundantly. This led to efforts to incorporate velvet bean into local recipes. Additionally, new recipes were developed based on their work with soybean, after changes to improve the taste and consistency.

Milton Flores of CIDICCO shares his own experience. "Although many people are eating the velvet bean in more than one (</resources/6a51acbc-90f8-42eb-ad30-d2c4b879fcfb>) way, we are careful to caution them to use it with care. We have observed symptoms such as drowsiness and headaches. This is especially true when people mix several [velvet bean] dishes at a time. In my own opinion, some people are more sensitive than others. I can stand only one cup of velvet bean coffee and one or two velvet bean tortillas at one time. When we have cooking demonstrations, with several dishes prepared and offered at the same time, it is usual that a couple people report symptoms like those I have mentioned. Most people, however, do not seem to be affected in any way."



A recipe book can make everything look very straightforward and safe. Eating velvet bean has not been proven to be safe, but it is safer than trying to live without protein. (I imagine other beans could be made to fit into these interesting recipes.) World Neighbors/ACORDE has made available the Spanish-English recipe book *Nutri-Cocina/Nutri-Kitchen*. It gives guidelines for using seeds of this productive green manure crop to prepare 23 foods. The toasted nutri-flour and mashed cooked beans are used to prepare hot, high-protein drinks, tortillas, doughnuts, ravioli, pasta, and several sweet cakes and desserts. Ingredients are simple and common, and the directions are complete and easy to follow. You can order the book for US\$7 plus postage: \$3 in US/\$7 overseas, from World Neighbors, 4127 NW 122 St., Oklahoma City, OK 73120-8869, USA; phone 405/752-9700; fax 405/752-9393; e-mail 635893@mcimail.com. If you are in Central America, contact the regional office of Vecinos Mundiales, Aptdo. Postal 3385, Tegucigalpa, HONDURAS; tel/fax (504) 32-7471. They are an excellent source of information on the uses of velvet bean in Central America. (https://cdn.ymaws.com/echocommunity.site-ym.com/resource/resmgr/a_to_z/azch11an.htm#Table)

ARE JACK BEANS SAFE TO EAT?

(<https://www.echocommunity.org/resources/145e7425-cc20-41af-9973-91032ce05a4d>) I have become uneasy recently. I can tell by letters that some of you are excited at the human food potential of the large seeds from the high-yielding jack beans (*Canavalia ensiformis*) that we sent. They are edible, but read the following cautions carefully. (You may react like one reader who was frustrated at my discussion of whether velvet beans are safe to eat. He wanted to know either "yes" or "no." Unfortunately, the world is often ambiguous.)

The book *Food Legumes* says, "The mature dry seeds can be used as food, but are not popular because of their unattractive (/resources/8a95a356-1443-4635-b7b6-c6d95b9c90bd) flavor and texture, and the fact that they require soaking and boiling in salt water for several hours to remove the toxic constituents and to soften them. [Ed: Flavor and texture might be less of a problem if beans were just one ingredient in a recipe.] In Indonesia they are often boiled twice, left in running water for 2 days after the removal of the seed-coat, then fermented 3-4 days and finally cooked once more." "Dried seeds can be used in livestock feed, but are not very palatable and can cause outbreaks of poisoning unless cooked or limited to less than 30% of the total feed."

Legumes in Human Nutrition says "the flowers, leaves and immature pods and seeds are used as vegetables." The *Handbook of Tropical Food Crops* says, "Foliage and seeds often contain poisonous substances and these have been implicated in occasional fatal poisonings. ...Apparently the amounts of poisonous substances vary with age of plant, maturity of seed, and possibly with environmental factors. Some varieties contain such small quantities of poisonous substances that they are commonly eaten and are considered harmless. There is no easy way to distinguish poisonous from nonpoisonous varieties. The commonly used varieties are not dangerously poisonous, judging from their popular usage."

Roland Bunch in Honduras says to "make sure people boil the bean and change the water twice. This means there will be an extra expense in firewood, but it is necessary to prevent ... problems." Tom Post in Belize says people there cut the immature pods into pieces and serve them in soups.