Germination as an Effective Method for Processing Jack Bean for Human Consumption

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The Resilient Agricultural Markets Activity – Beira Corridor Project

Starting in 2016, the five-year USAID Feed the Future Resilient Agricultural Markets Activity – Beira Corridor (RAMA-BC) supports local producers to raise agricultural productivity, profitability and resilience. RAMA-BC aims to advance adoption of sustainable and accessible farming technologies and practices. The use of legumes, including jack bean, pigeon pea, and cowpea, in cover cropping and intercropping is a key agricultural practice promoted by the project. These practices raise crop productivity, mainly maize, by enriching the soil and improving its structure, repelling pests, and reducing weeds. As a Feed the Future project, and seeing the potential for project activities to impact nutrition, the RAMA-BC project has introduced nutrition to its project activities. This document is a scientific justification for a food processing practice, detoxifying jack bean through germination, RAMA-BC has developed to take advantage of its agricultural activities to improve the nutritional status of its participants, as well as those outside of the project. RAMA-BC is also promoting germination as a method to improve the nutrient profile of all legumes.

Canavalia ensiformis, or jack bean, is a hardy crop with several useful properties. Like most legumes, jack bean contains various antinutritional compounds designed to make them unpalatable or toxic to pests and animals. These chemicals, along with jack bean's leguminous nitrogen fixing capabilities, can be advantageous for sustainable agriculture in that they are effective in repelling pests from other crops while gradually improving soil quality. Of all the beans that RAMA-BC uses, the jack bean is the most effective on both of these counts and also the most hardy, meaning it can be planted in conditions unfavorable to other beans while also surviving longer. It is also more prolific, often producing two harvests for a single crop, and its resistance to pests also means the harvest is not subject to post harvest losses from weevils, a major problem for other beans. All of this makes make jack bean an excellent food source as well, especially in periods of drought. However these same antinutritional compounds render the bean inedible to humans without special precaution.

The Nutritional Benefits of Germination

As stated before, many of the antinutritional compounds in jack bean are present in other legumes commonly eaten by humans and are responsible for the plant's notorious reputation as being hard to digest (Hamid and Kumar, 2017). Most of these indigestible compounds can be reduced by soaking for a day and cooking for an extended period, about one to three hours. In the traditional foodways of Mozambique, soaking and extended cooking are ubiquitous practices. However, germination further reduces

antinutrients that cooking does not fully eliminate, and some antinutrients *only* respond to germination. This makes it a valuable practice for all legumes in that it makes protein and minerals more bioavailable in addition to increasing some vitamins, mainly B vitamins (Soetan and Oyewole, 2009). Indeed, antinutrients can affect not only the nutritive value of the food in which they are present, but also reduce the availability of nutrients in other foods consumed.

The germination process is simple: beans are soaked for one day, drained, and then washed every morning and night until all beans germinate with a sprout about an inch long. For all beans, including jack beans, this usually takes 2-4 days of washing depending upon ambient temperature, and the age and species of the bean. In the case of jack bean, seed coats, or testa, are then removed and the bean is cooked for 90 minutes until the seeds have sufficiently broken down. This paper will further discuss the benefits of germination by exploring antinutrients that mainly respond to the process described. In the table below, one can see a list of the principal antinutrients in jack bean and how they respond to different processing methods.

Processing Methods to Eliminate Antinutrients

	Boiling	**Soaking**	**Germination**
Antinutrient			
Concanavalin A	1 hour	3 days	2-4 days
Other Lectins	1 hour		
Protease Inhibitors	20 min	1 day	2-4 days
Canavanine and Canaline	1 hour	–	2-4 days
Polyphenols and Polyamines	–	–	2-4 days
Phytates	–	–	2-4 days
Cyanides	1 hour	1 day	2-4 days
Urease	1 hour		

*Highlighted durations signify that the processes have to be done together

Antinutrients that Respond solely or mainly to Germination

<u>Polyphenos, Polyamines, and Phytates</u>

Many antinutrients are eliminated or effectively reduced in most legumes by soaking for a day and boiling for at least one hour, as is common practice. However, polyphenols and polyamines, which bind to iron and make it unavailable (Brune, Rossander, and Hallberg, 1989; Hurrel, Reddy, and Cook, 1999), are only reduced through germination and not cooking (Babar, Chavan, & Kadam, 1988). Phytates also inhibit the utilization of iron, as well as zinc and calcium (Brune, Rossander-Hulthe´n, Hallberg, Gleerup, & Sandberg, 1992; Hallberg, Brune, & Rossander, 1989; Onuegbu, Zibokere, Chinah, & Ukata, 1993). These nutritional components similarly only respond to germination and not cooking (Tabekhia and Luh). *Canavalia ensiformis* has also been

found to be naturally low in these compounds in comparison to other commonly eaten legumes, such as fava and soy beans (Rajaram and Janardhanan, 1992). This is promising, because RAMA-BC project beneficiary diets were found to be low in iron, with the principal source being dark leafy greens (Land O'Lakes) which are also high in polyphenols, polyamines, and phytates, rendering their minerals unavailable relative to other sources. More bioavailable sources of iron and other minerals would be an impactful addition to beneficiary diets. While animal products would be ideal, their availability and accessibility is often limited in the Beira corridor of Mozambique. Germination unlocks the potential of an already available food source, beans (including jack bean), to help fill this gap. The RAMA-BC project has taken advantage of this opportunity with a behavior change campaign that includes trainings, aimed at the adoption of germinating all beans and jack bean as a food crop

Cyanide

Cyanide is also an antinutrient present in jack beans and other crops in Mozambique - particularly cassava. Repeated consumption of cyanide-containing crops can lead to iodine deficiency and its associated disorders (cretinism and goiter), as well as several neurodegenerative disorders (Oke, Redhead, and Hussain, 1990). The only way to effectively reduce it is through germination along with dehulling, soaking and cooking (Okolie and Ugochukwu, 1989; Akpapunam and Sefa-Dedeh, 1997). Besides reducing cyanide levels in the bean, germination serves the important function of piercing the bean hull, making dehulling the bean much easier. This is the case for all beans and can reduce the labor burden of making certain value-added products that require dehulling, such as fried bean dumplings.

Concanavalin A

The most problematic and persistent antinutrient present in *Canavalia ensiformis* is concanavalin A (con A). According to Udedibie and Carlini (1998) "Con A negatively affects the nutrient utilization by different mechanisms. It binds to the glycoproteins and glycolipids of the digestive tract mucosa (Jaffe, 1980), inhibits the activity of the enzymes of the brush border of the enterocytes (Rosenthal, 1972), interferes with the adherence of the enterobacteria to the intestinal wall (Jayne-Williams, 1973) and possibly has several side effects on immune functions, protein metabolism, enzyme activities and hormonal regulation (Putsztai, 1989),". While con A is a lectin, which are normally destroyed by heat, it is hypothesized that the chemical make-up of jack beans make con A resistant to cooking alone, as the bean still presents hemagglutination activity after normal cooking practices. However, a few methods have been successful in removing the toxin: soaking the beans for 72 hours, breaking the dry beans into pieces before cooking for 30 minutes, and lastly cooking for 2 hours (Udedibie and Carlini, 1998). In the germination method that RAMA-BC recommends, beans are soaked for 24 hours and then washed and kept moist for at least 48 hours more, effectively soaking for 72 hours or more. Because germination helps break down the beans, after about 30-45 minutes of cooking they break

into pieces naturally. They are then further cooked for another 45 minutes to an hour, as is local custom, until they are sufficiently broken down into pieces. Therefore, the germination method employs a dual-layered strategy for eliminating Concanavalin A that is more fool-proof than one method alone, while also eliminating other antinutrients to raise the overall nutrition profile.

Potential for Adoption of Germination for Jack Bean and other Beans in Mozambique

Many areas of Mozambique are severely drought-prone, and Mozambicans plan accordingly. In the most affected regions, households choose to plant multiple varieties of cassava: the more edible, sweet, and less drought resistant varieties are planted alongside the less palatable, bitter and more drought resistant varieties. The bitter varieties must undergo a lengthy process of boiling, changing water, and being boiled again many times to become edible.

This same practice is employed with the jack bean in certain areas. This process is time and energy intensive, and most likely significantly reduces nutrient value. However, this means that Mozambicans, especially those most likely to benefit from jack bean, are already accustomed to the concept and practice of processing foods for detoxification. Germinated jack bean is also delicious, and due to its high protein content, many Mozambicans enjoy it more than other bean varieties. As one taste-tester at a village agricultural fair approved, “It tastes like there is meat but there is no meat,”. The practice of germination does not take significant effort, only advanced planning, and, as many Mozambicans have to process their foods from start to finish, the germination process is not seen as taxing or unfamiliar. Foodways in Mozambique for beans do not vary and involve cooking them until they significantly break down. This helps to ensure that concanavalin A will be eliminated when paired with germination. In addition, due to jack bean’s resilience, long growing season, and dual harvest, it is often available when other beans are not. These factors make jack bean an exceptional candidate for behavior change communication campaigns, which pair its agricultural utility as a nitrogen-fixing cover crop and green manure generator with its potential for alleviating hunger in a drought prone region. RAMA-BC has employed a comprehensive behavior change communication strategy to teach and promote germination to detoxify jack bean, as well as make other beans more nutritious, through radio spots, television appearances, agricultural fair and community demonstrations, pamphlets, technical briefs, and project participant trainings. The jack bean’s resilience makes it all the more important to promote the germination process for its human consumption, as farmers can be left only with jack bean in times of drought. Teaching the germination eliminates the risk for farmers eating the beans when toxic as well as providing an important food crop. Therefore, while jack bean is an excellent crop to promote in resilient agriculture training, teaching about the proper preparation of the legume for eating is critical for safe and successful nutrition outcomes.

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