THE ETHIOPIAN GRASS PEA 
(LATHYRUS SATIVUS): A BITTERSWEET SOLUTION TO FAMINE IN ETHIOPIA

UTS SCIENCE LORRAINE HOLLEY ESSAY PRIZE

KATE SAMARDZIC

Supervisors: A/Prof Ken Rodgers & Dr Matt Padula
Summary (100 words)

Amino acids are the building blocks of all life, and thus an inherent component of human nutrition. However, a subset of neurotoxic amino acids called non-protein amino acids (NPAAs) are known to appear in a variety of food products that otherwise appear to be ‘nutritious.’ Without proper knowledge of the underlying toxic mechanisms of NPAAs, many communities around the world have mistakenly fallen foul of NPAAs contained in their diet, leading to clusters of neurological disorders such as neurolathyrism, Alzheimer’s disease, Parkinson’s disease and Motor Neuron Disease. The aim of my research is to unravel the pathways, exact mechanism and extent to which NPAAs exert their toxic effects. This research could ultimately lead to innovative mechanisms for detoxifying foods containing NPAAs or treating individuals with adverse reactions to NPAAs dietary exposure.

Target Group (300 words) In this section identify the group that could benefit from your research and explain why that group fits one of the categories of poor, marginalised or disenfranchised.

In 2016 the United Nations Food and Agriculture Organisation estimated that about 795 million people were undernourished, with over 200 million of those experiencing hunger residing in Africa [1]. Since 2016, Ethiopia, a country whose history is blighted by famine, has been experiencing one of its worst droughts in decades due to a powerful El Niño weather event that disrupted normal rainfall. As a result, more than 10 million people (greater than 10% of the total population) and including 6 million children are at risk of hunger, disease and lack of water in Ethiopia [2]. In June 2016, UNICEF predicted that 2.5 million children and pregnant and lactating women were expected to be treated for malnutrition. Compounding this issue, a total of 366 woredas (districts) are at risk of disease outbreak and require aid from emergency relief programmes as a result of the devastating El Niño drought (Figure 1) [2].

The leguminous grass pea (Lathyrus sativus) (Figure 2) is enticing to poor malnourished farmers in Ethiopia as it prevails where most crops are scorched by the resulting harsh environment. As a feature of evolution, the nutrient dense grass pea is naturally hardy, with crops capable of withstanding extreme temperatures, drought and flooding. Evolution has also gifted the grass pea additional protection from insect predation and plant competition in the form of the allelopathic NPAAs β-N-oxalyl-L-α,β-diaminopropionic acid (BOAA)[3]. Prolonged consumption of BOAA in periods of famine leads to neurolathyrism or ‘Yeguaya beshita’ in Amharic (official language of Ethiopia), a neurological disorder characterised by irreversible paralysis of the legs [4].

To add to the devastating neurological effects of neurolathyrism, in Ethiopian culture, symptoms of this disease often lead to discrimination and social alienation within the community [5]. This is compounded by the fact community members would not seek any intervention if a family member developed the disease, as highlighted in the results of a 2002 community survey where 86% of respondents answered in the affirmative [6].

International aid agencies, donors and governments are currently operating emergency food assistance programs in Ethiopia but unfortunately, as many other countries are in need
of assistance due to conflict and drought, with only finite aid resources available, the grass pea may become a seemingly viable food source for many who are experiencing famine.

Figure 1. Emergency relief programme Priority status of woredas (districts) in Ethiopia as of March 2016 (Unicef), woredas are classified as First Priority (red), Second Priority (orange) and Third Priority (green) according to their urgency.

Figure 2. Grass pea (Lathyrus sativus) plant flower, seedpods and seeds. In Ethiopia powdered seeds are used in shiro wot (a traditional spiced soup dish), split to form the sauce kik wot, roasted and served as the snack kollo, boiled to serve as nifro or ground into flour and made into the flatbread kita [7]. (Image credit: H. Zell)
Research Work (300 words) In this section describe your research project and findings, clearly differentiating the work you have completed from the work you are currently doing.

My research aims to investigate a range of NPAAs to determine their toxicity and the mechanism whereby they exert their toxic effects. I began my research by demonstrating the allelochemical properties of BOAA, which allow plants such as the grass pea to outcompete other plants, in the common crop plant alfalfa (*Medicago Sativa*) (Figure 3). I have also performed *in vitro* toxicological screening studies on 6 different NPAAs in a cell line modelling neurological disease, 4 of which were positive for toxic effects, and investigated 4 protein amino acids (L-serine, L-Isoleucine, L-Leucine and L-Valine) that conferred protection from NPAA toxicity.

To date, I have studied one NPAA in more detail to understand the potential mechanisms of cell death using bioassays to examine oxidative stress and fluorescent microscopy to examine cell lysosome activity and mitochondrial dysfunction. In the future, I will study another NPAA, BMAA, using the same techniques and compare the mechanisms of the two to determine mechanistic similarities that are unique to NPAAs. Like BOAA, BMAA exposure occurs through the diet and has been linked to neurodegenerative disease. However, BMAA linked neurodegenerative disease affects indigenous Chamorro people of the West Pacific island of Guam. Once I have determined the mechanism of toxicity, I can then begin developing methods to mitigate the effects of NPAAs using varying concentrations of the protein amino acids I have discovered offer protection during the course of my research.

The next step, in the final year of my PhD, is to utilise proteomic studies to view the pathways involved in NPAA toxicity with the overall aim of finding interventions that target these pathways to neutralise NPAA toxicity.

Figure 3. BOAA decreases the growth of alfalfa (*M. sativa*). This figure demonstrates that BOAA can negatively affect the growth of the crop plant alfalfa at a wide range of concentrations. This is important as this property adds to the resistance of the grass pea,
allowing it to outcompete other plants that are nearby and increasing the likelihood the grass pea will be consumed.

How the research could benefit the target group (300 words)

The grass pea is a promising crop due to its immense capability to endure environmental and insecticidal stress. If I can discover a method to mitigate BOAA toxicity the grass pea crop would have a tremendous effect on the food stability of millions of Ethiopians suffering from famine. Over the last decade there have been many attempts to diminish the neurotoxic effects of BOAA by modifying the genetic composition of *L. sativus* seeds and employing various agronomic practices [8]. However, due to the lack of consistent information, many Ethiopian farmers are unsure of effective practices and therefore employ a wide variety of techniques, mostly ineffectively due to misinformation. The initial stages of my research, i.e. identifying the allelochemical properties of BOAA in the grass pea, would benefit Ethiopian farmers by contributing to their knowledge of the grass pea plant. With efficient information distribution, farmers could be on the lookout for solitary-growing plants, aiding in their identification of the grass pea and decreasing the risk of accidental consumption.

Further, my discovery that protein amino acids offer protection from NPAA toxicity could lead to the formulation of a supplement that could act as an antidote to the deleterious effects of grass pea consumption. This supplement could be distributed by aid organisations and as protein amino acids are already widely used as supplements, offers a solution that is affordable, accessible and can be implemented in a timely manner without the need for the lengthy process of drug development. Communities experiencing famine could potentially rely on the grass pea as a nutritional source if taking the amino acid antidote, increasing food security.

Finally, an increased understanding of the mechanisms and pathways involved in BOAA toxicity could lead to the development of a medication that could help alleviate the symptoms of those already afflicted with neurolathyrism. This would greatly improve the quality of life of those affected by this devastating illness.