Presenter: Associate Professor Ros Gleadow - *2016*

***Title: Plants that kill: How climate change is changing our food.* (16:21)**

Time	*Dialogue*
00:013 00:37	Potatoes. … Have you ever been told that you shouldn't eat green potatoes? So maybe this was something your grandmother said or maybe you thought it was an old wives tale. Well actually it's true. Potatoes contain a toxic chemical, called glycoalkaloid and it can make you really sick. Causing vomiting, diarrhoea, stomach cramps and in extreme cases death and the amount of those alkaloids is much higher in the green parts of the plant so you shouldn't eat the green parts. Now plants make lots of different types of toxic chemicals and they do this because when they get attacked by a pest they can't run away. They have to stay and defend themselves and a lot of them do this with toxic chemicals and potatoes do this with alkaloids.
01:00 01:35	Back in the 1960's they developed a new variety of potato that was absolutely fantastically resistant to pests and when they released it to farmers, farmers didn't always grow it under perfect conditions and it maybe got a bit drought stricken. They put them into the market, people bought them and people got really sick. So they took those potatoes off the market. So you can be sure that the potatoes that you eat in the supermarket are safe because ever since then every variety of potato that is developed is tested before it is released to market. So I work on a different toxin. I work on plants that make cyanide and you may be familiar with these in apple seeds that taste the inside of the apple seed, bitter almonds. About 30 different types of eucalypts, about 1 in ten plants. So a lot of plants make cyanide and marzipan. You know that smell of marzipan? Not everyone can smell it. In fact that is the smell of cyanide however the levels in marzipan are very low. Marzipan is not going to kill you.
02:06 02:30	And it's quite safe in marzipan because the amount you can eat depends on how big you are and on what else you are eating, if you are eating protein. If you are eating a certain amount of protein you can actually detoxify the cyanide and you excrete it in your urine and you're OK. But it you eat a lot of cyanide it can cause toxicity and that will depend on how big you are. So for someone my size, I need to eat about 60 milligrams of cyanide to kill me. It's actually not a lot. So I worked out for example, that on an apple core that had a lot of seeds in it I probably need to eat about 30 apple cores to kill me and for this particular eucalypt, it's a sugar gum leaf, I actually measured this leaf and worked out how many of these leaves would kill me and I would have to have 30 full grown leave finely ground, eaten all in one go if it was going to kill me. So it is actually very toxic.
02:57 03:27	So how did I get into this? Well I was really fortunate. I grew up … that's me, I grew up in a family that valued education. Both my parents were medical doctors and I grew up thinking that I would become a doctor. I wanted to become a doctor, in fact my parents were very outward looking and I wanted to go to Africa and save the world. I always thought I wanted to do that. But when I got into High School I got interested in all kinds of other types of biology. Animal biology, plants really attracted me, genetics, and so when I left school instead of studying medicine I enrolled in a science degree and did a major in botany. In my family that was actually a very rebellious thing to do. So I when on and ended up doing a PhD in botany in plant animal interaction and in particular on a group of eucalyptus that make cyanide and I was looking at the effect of climate change and how that might affect animals that might feed on the eucalypts in future time, for example koalas.

Time	*Dialogue*
03:41 04:17	But as I read about this I became more and more aware that there was a lot of cyanide in crop plants. In fact one in five crop plants contain cyanide so, I realised that this was actually causing some issues for health around the world and one particular crop is this tuber in the front called Cassava. This is a street stall. Tubers are very important for food security around the world and cassava is very very important for feeding people. A billion people eat it every day. We don't eat it much in Australia but it is very important, however it can actually be very high in cyanide and in fact it is the only staple crop that can kill you if it is not properly processed. That's apart from green potatoes.
04:40 05:05	So people do die. Probably every day a couple of people around the world would die from eating cyanide from eating unprocessed cassava but mostly it is associated with neurological disorders … for example paralysis. So these children here have a disease called Konzo. It's a paralysis of the lower limbs and once it's developed it's permanent. And this was first, diagnosed as a disease, identified as a disease around about 1980 by a Melbourne doctor called Dr Julie Cliff. She was working Mozambique and she was going around and there was this new disease. A real epidemic and a lot of it and they didn't know what it was and they thought it was some type of Polio or something else like that so they went around and the people kept saying that it was something to do with the food, … and eventually she drew the connection between the high cyanide in the Cassava and the paralysis and so she realised it was actually something to do with the food and it was cyanide.
05:41 06:05	Now around about this time there was another Australian researcher, a guy called Howard Bradbury and he retired around about this time from the chemistry department at ANU (*Australian National University*) and was looking for a retirement hobby and he was really interested on the effects of cyanide on human health and he got in touch with Julie and they decided that they would test the flour in the market places. And they found that in a normal year the flour that is made from Cassava has about 15 to 20 part per million cyanide but in fact in a drought year it was 10 times as much, over 200 part per million. Now the World Health Organisation's (WHO) recommendation for food is to have less than 10 parts per million cyanide so you can see even in a normal year it is above what the recommendation is. So I was reading about these things while I was working on eucalyptus and I really thought that I'd been looking at the effect of climate change on how these plants were changed and I wanted to know what would happen to Konzo.
06:37 07:08	So would the cyanide in Cassava change as I was seeing with the eucalypts? So we have rising carbon dioxide, increasing global temperatures and while the world as a whole may be wetter in the future the parts of Africa where the people rely on Cassava is predicted to get much dryer. So as a result of this I got in touch with Julie and I got in touch with Howard and other researchers and I set up a whole series of experiments and most of these have been done at Monash by a range of different students and colleagues. And we have grown the plants at high carbon dioxide and low. We have watered them and droughted them, rewatered them. We have grown them in hot conditions, warm conditions. Cassava doesn't grow in cold conditions and we have applied salt water to them to see what the effect of sea level rise might be. So we have done all of these experiments and I'm just going to tell you about one of those now.
07:32 07:56	So this is an experiment that was done by two honours students that looked at different aspects of the one experiment and they had about 100 cassava plants and they were either watered or droughted. The drought was imposed by weighing the plants and reapplying about 25% of the water that they had lost. So they did this for a couple of months. They took lots of samples of the leaves, the stems and the tubers so we could analyse them chemically and then they/she took half the droughted plants and then rewatered them for a few weeks to see if the plants would recover. So what they found was not unsurprisingly plants that had access to water had bigger tubers. That's not surprising. The plants that were droughted only had very small tubers. These plants were quite young. Only 6 months old.

Time	*Dialogue*
08:22 08:46	Interestingly after even only two months of rewatering the tubers were in fact starting to develop again in these plants so it does suggest that rewatering is quite a good way to increase your yield. But what was happening to the cyanide? Well this graph shows the amount of cyanide in the droughted plants on the right and the watered plants on the left so you can see the droughted plants have much more cyanide than the watered plants. That red line is the World Health Organisation's (WHO) recommended level for the maximum amount of cyanide in food. So this confirms and in fact was the first study that shows definitively that drought increases the amount of cyanide in cassava. So the reason you get Konzo epidemic in drought times in not just because people are eating more cassava but because the cassava itself contains more cyanide.
09:08 09:29	But the other interesting thing that these girls discovered was that when we rewatered the plants was that the cyanide concentrations came right down in the tubers even though they had only been rewatered for two weeks. This actually suggests that there could be a simple intervention that if people did have access to irrigation water they could water the plants just for a week or two before they harvested them and it may actually make them safer to eat. This is just a hypothesis and it hasn't been tested yet but it's a good idea that someone should do. So we did all these experiments and tried to work out how to predict what will happen to cassava in the future and like so much of science it's complicated.
09:49 10:09	So we found that drought increases the toxicity, carbon dioxide increases the toxicity mainly through reducing the protein levels. Temperature effects the cyanide levels and then there is all kind of odd interactions so if you have a high temperatures, the drought gets more severe. So that's an interaction. There's weird interactions between carbon dioxide and drought, There's interactions between temperature and carbon dioxide, so all in all this makes it very difficult to predict what is going to happen in the future and really a better thing would just be to have no toxins in the cassava at all. So why don't we try to genetically engineer cyanide out of cassava and improve it that way?
10:27 10:55	So in terms of removing cyanide from cassava there is really three different routes. The first one is don't eat it. The second one is genetically modify it and the third one is change the processing method. Not eating isn't really realistic. This is a really important food security crop. A billion people eat it every day. Forty percent of sub-Sahara Africa live on it, so it is not feasible to not eat it, however what you could do is as you can tolerate cyanide if you have some more protein in your diet, the thing to be is lift people out of poverty so they can improve their diet. So people can incorporate fish or vegetables into their diet so they are less likely to get diseases and Konzo. And in fact people living on lake shores almost never get Konzo and you never see it in those conditions. So that's one thing. In terms of genetically modifying (GMO) cassava there are a lot of perspectives about this. So for example scientifically it is possible, right. So it's been done.
11:32 12:04	Groups have done this and we have done this for a different plant that also makes cyanide and what we have all found is that there is some type of weird trade-off between growth and cyanide. So when the plants are young, it turns out that the plants without cyanide are a bit slower to get going. We are not quite sure what is going on and that's ongoing research. There is something there and when you genetically modify organisms you can get some inadvertent consequences, so we are not quite sure but it can be done and it has been done. Politically there are some issues. Many people don't want to eat genetically modified organisms and some countries in Africa have a ban on growing GMO's so that's not realistically politically and also in terms of not being realistic, are that these people are very poor so they are not going to be able to buy some kind of expensive technology. So if they were going to use GMO cassava it would have to be given to them or provided philanthropically.

Time	*Dialogue*
12:28 13:03	And the third issue around that is the social aspect and it turns out that there is actually a preference for eating high cyanide cassava. Now you think that's weird? Why should people do that? Well first of all they are probably more pest resistant. So that's one thing. But another thing is the women do the processing and high cyanide cassava in Africa puts women in charge of the food change. So people won't come and steal your crop. If you have soldiers going through they are not going to take your food because it has to be processed and this way the women can control the food supply so it's actually very important socially and I think this illustrates the points that scientifically we can come up with all kinds of great alternatives for reducing cyanide but in the end you've got to work with local people and see what's acceptable.
13:20 13:48	So that leave processing and there are many different ways to process cassava. Some of them are very effective and some are less effective. In Nigeria they tend to use a fermentation process which is reasonably effective for normally grown cassava and it tends to make the product quite sour tasting and that is not acceptable in Southern Africa. They don't like the taste so what they do there is they either soak the cassava and cook it or they grind it up into a flour and make a kind of chapatti out of it. That's the most common way to eat it in Southern Africa and Its not particularly effective at taking the cyanide out. So Howard who has spent the last 35 years now since his retirement working on this problem has done two things.
14:09 14:30	First of all he has developed test kits which are given to plant breeders in Africa so they can test the plant varieties so they don't have these really high cyanide varieties. And the other thing is he has developed a new very simple method for reducing cyanide in the food crop. He calls it the wetting method. And what he has done is introduced a step between mixing the flour with the water and the cooking. And if you add another step in there where you spread that out and you leave it in the sun or you leave it in a warm place the cyanide just goes off into the air and it is so effective it reduces the amount of cyanide in the food by 95% and renders it completely safe. So it is a very simple system, however it is quite challenging to change people's way that they treat their food and he has produced a lot of brochures.
15:01 15:29	You can see here a picture of a boy with Konzo and a step by step guide is available in about 40 different languages. In parts of Mozambique where they have rolled this out in collaboration with Julie Cliff and the other Mozambique workers this has been very effective in reducing disease in those areas. So it is a highly effective method. It's been very effective in the Congo. They have done interventions there and everywhere they do the interventions they don't see any Konzo. So normally in a village you might get one or two cases a year or one or two cases every couple of years with epidemics during droughts. Since they have introduced these measures they don't get any. It's highly effective and it's very very simple.
15:46 16:09	I've come full circle. I did actually become a Doctor. I've got a PhD in Botany and I have worked to improve human health in Africa. So in conclusion I would just like to leave you with a word of advice. If you want to save the world or you want to make a difference, don't study medicine … study plants. Thank-you.