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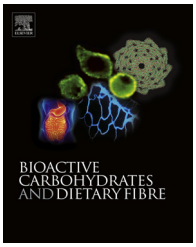

The anti-diabetic potential of polysaccharides extracted from members of the cucurbit family: A review

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ABSTRACT

Diabetes is a growing global problem and a heavy financial burden on health care services. It is estimated that over 380 million people suffer from this condition which causes many deaths each year in addition to being associated with increased risk of other health problems. Traditional medicine is a promising area of research in diabetes therapy as it is widely accessible and it is believed that over 200 plants have anti-diabetic properties including members of the cucurbit family. Studies in animal and human models have shown that treatment with some cucurbits has hypoglycaemic effects and stimulates beta cell regeneration in addition to other anti-diabetic effects which are equal to that of commonly prescribed anti-diabetic drugs. It has also been shown that at least one of the bioactive components which stimulate these effects is a polysaccharide.

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1. Introduction

Traditional medicine is the only medicine available to 75% of the planet's population (Yamada, 2008) therefore it is of significant interest. Carbohydrates and glycoconjugates are important in disease related applications including traditional medicine (Rudd & Dwek, 2006). Plants are often used in traditional medicine with over 200 species thought to be beneficial in the treatment of diabetes (Jia, Gao, & Tang, 2003), many of these traditional medicines are thought to have active polysaccharide components (Fu, Shi, & Li, 2006).

The *Curcurbiteae* family, also referred to as cucurbits (Fig. 1), are a group of fruit producing plants (Weng & Sun, 2012). They form a very large group with approximately

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Fig. 1 – Seen on this image is a selection of cucurbits of the South Korean Genebank in Suwon (2010). Including luffas (*Luffa aegyptiaca*), wax gourds (*Benincasa hispida*), bottle gourds (*Lagenaria siceraria*), snake gourds (*Trichosanthes cucumerina*), pumpkins, gourds and squash (*Cucurbita sp.*). Reproduced with kind permission from Crops for the Future (http://www.cropsforthefuture.org/).

130 genera and 800 species and can be cultivated worldwide (Dhiman, Gupta, Sharma, Gill, & Goyal, 2012). Popular cucurbit food crop species include pumpkins, squashes, gourds and melons (Huang, Tan, Tan, & Peng, 2011; Noelia, Roberto, de Jesus, & Alberto, 2011; Behera, Sureja, Islam, Munshi, & Sidhu, 2012; Song et al, 2012; Weng & Sun, 2012).

Cucurbits are of interest because of the extensive range of medicinal properties they have been reported to exhibit (Dhiman et al., 2012). Traditional medicine, particularly the Chinese (Fu et al., 2006) and Ayurvedic systems (Chaturvedi, 2012), have made use of various parts of cucurbit plants; including the seeds and flesh of the fruits they produce (Dhiman et al., 2012). There are reports of traditional medicinal polysaccharides exhibiting a number of important physiological properties including: tumour growth inhibition, wound healing, immunomodulating and hypoglycaemic effects (Fu et al., 2006; Inngjerdingen et al., 2007; Košťálova et al., 2013).

It is believed that over 200 plants have blood glucose lowering properties, including many common plants such as those belonging to the cucurbit family (Jia et al., 2003). The active ingredient of several of these cucurbit extracts has been shown to be a polysaccharide such as that found in pumpkin (Fu et al., 2006). Yet currently plant polysaccharides as medicines are under researched. Polysaccharides can be difficult to characterise due to their natural variability in terms of composition, structure, molecular weight and conformation. The polysaccharides found in the fruit of a plant may differ due to many factors including the fruit development (Li, Fan, Liu, Yang, & Shen, 2006), ripeness of the fruit and the environment in which the plant was grown (Dong et al., 2003). Polysaccharides are less researched than other bioactive molecules such as proteins because they are more difficult to work with, they are more difficult to obtain as they are not coded for directly, they are also relatively easy to break down in digestion so delivery mechanisms would need to be looked at more carefully (Duus, Gotfredsen, & Bock, 2000).

It is known that, like proteins, polysaccharides are capable of interacting with an organism causing a change in biological activity (Yang & Zhang, 2009). The interaction and effect of the interaction varies greatly due to the conformation (Yang & Zhang, 2009) and other potential interactions of the polysaccharide (Patel et al., 2007; Heinze et al., 2011). Polysaccharides are known to be able to modulate the immune system through the stimulation of macrophages (Schepetkin & Quinn, 2006) have anti-tumour effects (Wasser, 2002), reduce inflammation (Wu, Duan, Liu, & Cen, 2010) and act as a hypoglycaemic agent (Xiong & Cao, 2001; Zhang & Yao, 2002; Cai, Li, Yan, & Li, 2003). Polysaccharides from food plants such as the cucurbiteae family may make very good medicines as they are often eaten in the diet and are therefore unlikely to be harmful to the patient (Wang, Zhang, & Dong, 2012).

Glucose is the source of energy used by the brain so it is essential that there is always glucose in supply in the body, including in times of fasting (Rang, Dale, Ritter, & Moore, 2003). More energy is available in the food we eat than is needed in one burst so in healthy individuals the excess is stored as glycogen or fat (Rang et al., 2003). The most important hormone in the regulation of how much is stored and how much is used is insulin. The greater the level of insulin the greater the amount of glucose is stored. However when blood sugar levels drop the insulin produced is reduced and there is an increase in the production of other hormones including glucagon, adrenaline, glucocorticoids and growth hormone which increase the levels of blood sugar through conversion of stored energy back to glucose (Rang et al., 2003).

Diabetes mellitus is a fairly common condition arising from defects in production or action of insulin which causes hyperglycaemia (Nelson, Lehninger, & Cox, 2008). Non-diabetic humans have a blood sugar level of between 4 and 7 mmol/L however non-controlled diabetic patients have a much higher concentration of glucose in their blood. If left untreated many complications can arise, which may even lead to death (Yadav, Morris, Harding, Ang, & Adams, 2009).

The high prevalence of diabetes and other health issues associated with this disease is a financial burden on already stretched health care services. A study of health problems with U.S. patients with diabetes showed that sufferers are more likely to suffer from fair or poor health than non-sufferers (Gregg et al, 2000). These health problems include heart problems, kidney disease, impaired vision, limb loss and general poor health than non-diabetic patients in addition patients will need on-going health checks and, in many cases, insulin (Yadav et al., 2009). Diabetes influences the quality of life of the patients as well as forcing them to undergo lifestyle changes such as regular monitoring of their blood glucose levels (Smyth & Heron, 2006). It is estimated that over 380 million people suffer from this condition (Fig. 2) and is the cause of more than 2.9 million deaths each year (Yadav et al., 2009) these figures are also projected to rise over the next 30 years. The majority of people suffering from