Rice with Low and High Glycaemic Index (GI) Interacting with Oils: What Do We Know So Far?

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INTRODUCTION

Rice (*Oryza sativa*) is a staple food of 3.5 billion people worldwide and is mostly consumed in Asia (Mohanty, 2013). Rice provides energy and makes up around 35%-59% of total caloric intake (Meng *et al*., 2005). White rice is the most widely consumed form, while unmilled brown rice is also regularly consumed in some countries. There are various types of rice available in the market. White rice is mostly classified as long-, medium-, and short-grain. Basmati, parboiled and jasmine rice are the favourite types of rice in Asian countries (Kaur *et al*., 2016).

HEALTH RISKS FROM EATING RICE

Rice is an important component in the Asian diet, and is often eaten during breakfast, lunch and dinner. Besides boiled rice, food made from rice is widely used in Asian cooking. Rice noodles are often eaten by the Chinese and Japanese, whereas the Indians love their *idli*, *thosai* and string hoppers which are all made from rice flour. Rice is categorised as a food with medium to high glycaemic index (GI). Long-term consumption of rice can be detrimental to human health, leading to the development of various chronic diseases such as diabetes (Hu *et al*., 2012), dyslipidaemia (Ludwig, 2002), obesity, breast cancer (Sieri *et al*., 2007), endothelial dysfunction, cardiovascular disease (Venn and Green, 2007) and decrease in cognitive functions (Nakashima *et al*., 2010). High intake of rice is associated with an increased risk of type 2 diabetes mellitus in Asian populations (Mohan *et al*., 2009; Nanri *et al*., 2008; Murakami *et al*., 2006). A Japanese study conducted on children reported that the intake of white bread compared to boiled white rice during breakfast caused a lower increase in glucose levels (Taki *et al*., 2010). This is because of the GI level of white bread is lower compared with boiled white rice. Another study done on a US population showed that substitution of white rice with lower GI brown rice significantly reduced the risk of developing diabetes (Sun *et al*., 2010).

RICE AND GLYCAEMIC INDEX (GI)

Glycaemic index measures how a food containing carbohydrate raises blood glucose levels. Foods are ranked as high-, medium- and low-GI, based on their plasma glucose-raising potential when compared to a reference food, which is either glucose or white bread. GI values of foods are usually measured by *in vitro* studies or acute human trials.

The GI value of a food is determined by an acute human trial with 10 or more healthy subjects. Food containing 50 g of carbohydrate is given to each subject, and the blood glucose levels are monitored over two hours. These plasma glucose levels over time are plotted, and the area under the curve (AUC) for glucose is measured. The same 10 subjects will then have to consume 50 g of glucose sugar or a reference food on a different day, and their two-hour blood glucose responses are measured as before. The GI value for the test food is then calculated for each person by dividing their AUC of glucose for the test food by their AUC of glucose for the reference food. The final GI value for the test food is the average GI value for the 10 subjects.

Usually a food with high GI produces a rapid rise and fall in the level of blood glucose. In contrast, foods with a low and medium GI usually contain slowly digested carbohydrate that produces a gradual, and relatively smaller or lower rise in the level of blood glucose. The blood glucose-raising effects of high-, medium- and low-GI foods are depicted in *Figure 1*.

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Rice is generally categorised as a medium–high GI food, because compared with other starchy foods rice starch is readily hydrolysed by amylases after ingestion (Frei *et al*., 2003). Carbohydrate-rich foods are divided into three types; low GI (< 55), medium GI (56 - 69), or high GI (> 70).

FACTORS AFFECTING GI OF RICE

GI of a starchy or carbohydrate-rich food is affected by its digestibility. There are various factors affecting digestibility of starch, such as cooking (Fernandes *et al*., 2005), its amylose content (Hu *et al*., 2004) and the presence of fat, protein and fibre (Clegg *et al*., 2011; Brand-Miller *et al*., 2010; Jenkins *et al*., 2010; Henry *et al*., 2008). Rice is predominantly eaten plain and boiled, or in a steamed form, with other condiments such curry, vegetables and proteins. However, it is also often made into various dishes such as fried rice, *briyani* and *pilaf* where fat is added for flavour, aroma and texture.

EFFECTS OF INTERACTION OF RICE WITH OILS ON GI

Oils and fats are traditionally added to rice in Asian cooking to enhance its flavour. For example, fried rice is a widely consumed rice dish among the Chinese, Malaysian and Indonesian populations, whereas *briyani*, ghee rice and *pilaf* are commonly eaten by the Indian and south Asian populations. Addition of oil to rice not only makes the rice tasty but also cuts down on the calories from rice by lowering its GI (Kaur *et al*., 2015; Thomsen *et al*., 1999). Aston *et al*. (2007) investigated GI of Basmati, easy-to-cook Basmati, and easy-to-cook American rice after the addition of margarine. The GI values reported were 43, 68 and 49, respectively, for each rice type. In contrast, the plain forms of these rice have a relatively higher GI (Ranawana *et al*., 2009). The addition of fat may have reduced the glycaemic response by delaying gastric emptying and enhancing the secretion of gastric inhibitory polypeptide (GIP) (Ercan *et al*., 1994; Collier *et al*., 1984; Collier and O'Dea, 1983).

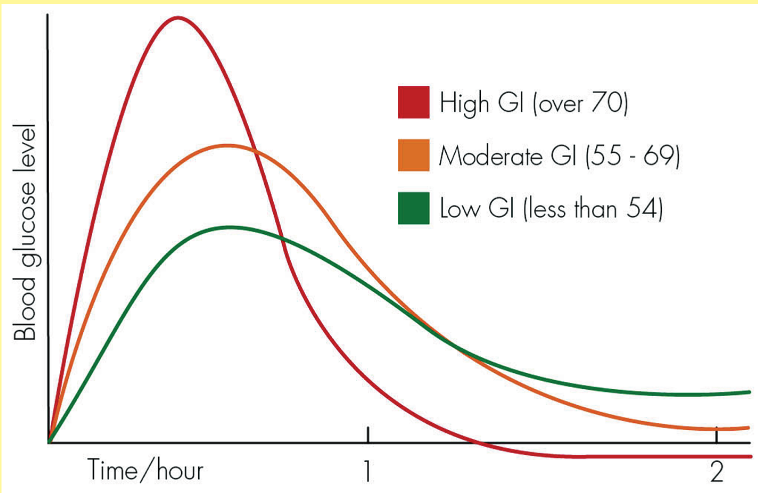

Figure 1. Glycaemic index graph.

An *in vitro* work by Kaur and co-workers (2015) shows how oil type and time of addition of the oil to the various types of rice (white and red) affect starch digestibility. The two types of rice cooked with different oils added at different times were subjected to *in vitro* enzymatic digestion under controlled conditions. An unsaturated vegetable oil (soyabean oil) and saturated ghee were used in the study. These oils are used traditionally to make flavoured rice in Asia. The oils were added either 'before', 'during' or 'after' cooking the rice. Stir-frying of cooked white or red rice resulted in more slowly digestible starch, and showed potential for decreasing the postprandial glycaemic response and for increasing the resistant starch content (Kaur *et al*., 2015).

A recent study by Farooq *et al.* (2017) shows the effects of palm oil on the structural changes and *in vitro* digestion of cooked rice. Cooking rice with palm oil increased amylose-lipid complexes (ALC) and a significant reduction in the digestibility of the rice was displayed. This suggests that cooking rice with palm oil can significantly alleviate the glycaemic load of the rice (Farooq *et al*., 2017).

A human trial reported that the glycaemic response to a high GI Jasmine rice was attenuated when co-ingested with groundnut oil. The magnitude of reduction was two times more compared with low GI rice (30 *vs.* 15%) (Sun *et al*., 2014). More human trials are needed to confirm these findings, and future studies with different types of cooking oil and on the physiochemical structure of ALC of rice are needed to confirm the effect of interactions of cooking oils/fats with rice on glucose homeostasis.

PALM OLEIN AS A GOOD CHOICE TO REDUCE GI OF RICE

A cooking oil like palm olein will be an excellent choice to be used in experiments with rice, as palm olein has equal amounts of saturated fat and unsaturated fat. Furthermore, recent work has shown some interesting preliminary findings (Farooq *et al*., 2017). Palm olein can be a healthy tool for reducing the GI level of rice. Adding cooking oil during cooking causes the oil to enter the starch granules during the cooking process and adds a protective layer, which later forms ALC. ALC is an indigestible starch which is resistant to digestive enzymes (Ai *et al.*, 2013). The amylose-lipid interaction occurs when the linear amylose fraction interacts with the added lipids to form single-helix complexes (*Figure 2*). During cooking, the formation of ALC can reduce the solubility of starch in water, alter the physiochemical properties of starch, decrease swelling capacity, increase gelatinisation temperature, and decrease retrogradation and gel rigidity (Copeland *et al*., 2009). From a nutritional point of view, the lipids in starchy food systems affect starch digestibility. On one hand, the presence of lipids slows down the retrogradation of starch, thereby inhibiting the formation of resistant starch. On the other hand, the resultant ALC is resistant to enzymatic digestion (Blazek *et al*., 2011). Ultimately, this means that fewer calories from the rice are absorbed by the body.

CONCLUSION

Rice is the main staple food in Asian countries. However, it contributes a large glycaemic load to the diet, and subsequently promotes impaired glucose homeostasis. Advocacy to reduce rice consumption may not be a sustainable solution. Reducing GI of rice may be a more practical approach. Addition of oil into rice is an excellent way of reducing the overall GI of rice meals. This will also change the physicochemical and sensory properties of the rice. Future studies are needed to focus on the oil and fat interactions with rice and their effects on GI, for developing a healthy rice meal. Such developments are urgently needed not only to enable consumers to enjoy the delights of eating rice but also to ensure better health outcomes.

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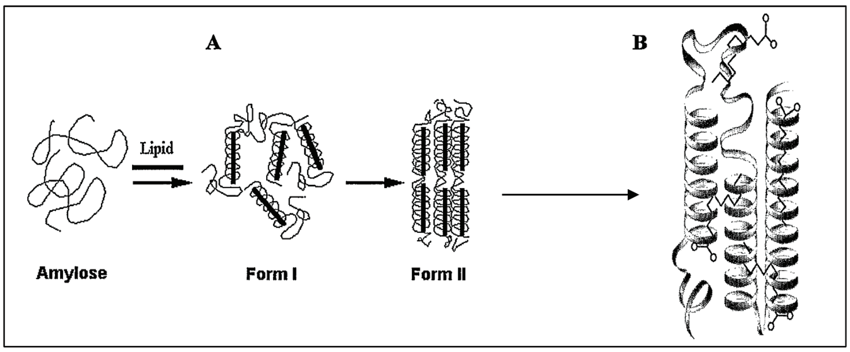

Amylose-lipid complex (ALC) **Resistant to digestive Enzymes**

Figure 2. Formation of amylase-lipid complex.

Effects of palm oil on structural and in vitro digestion properties of cooked rice starches. *International Journal of Biological Macromolecules*.

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