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The Effect of Fibre in Fruit and Vegetables on Colorectal Cancer

Fibre is defined as indigestible remnants of plant carbohydrates. They are classified as indigestible as they cannot be broken down by the body's enzymes (Perez-Cueto and Verbeke 2012). It is a major component in fruit and vegetables, as well as in other foods such as cereals and grains. Increase in dietary fibre intake is shown to lower the risk of colorectal cancer (CRC) development, especially with respect to distal colon cancer (Kunzmann et al., 2015). Generally, an intake of 10g of fibre daily has shown to reduce CRC risk by 10% (Song et al., 2018). This, however, mainly refers to the progression of adenomas to CRC. (Kunzmann et al., 2015). Moreover, evidence has shown that patients who ingested greater amounts of fibre prior to being diagnosed with CRC tended to have a lower mortality rate, with CRC mortality decreasing by 18% with every 5g of fibre consumed. Studies conducted by Kunzmann et al., (2015) did not establish any strong relationships between risk of recurring adenomas and fibre intake, irrespective of the source of fibre, site of adenoma or adenoma progressivity. Research also showed that increasing fibre consumption post-diagnosis of CRC can increase survival chances (Song et al., 2018).

Fibre is classified into 3 different categories: soluble; insoluble; and pectins. They exhibit different degrees of association with CRC risk, with a strong inverse linear effect between insoluble fibre intake and CRC risk (Navarro et al., 2016). Patients consuming greater amounts of fibre are more likely to present with stage I CRC rather than stages II or III, which are more severe. (Song et al., 2018). An effect was also recorded for fibre from cereal and vegetables, with cereal fibre imposing a more potent effect on CRC reduction compared to vegetable fibre, due to its greater fibre content (Ben et al., 2014 as cited by Navarro et al., 2016). On the other hand, no relationship was established between CRC risk and fibre from fruit (Song et al., 2018) except for Kunzmann et al., (2015) who reported a strong protective relationship in fruit

fibre. Such discrepancies may potentially be due to cereal fibre being insoluble, in contrast to fibre in both fruit and vegetables, which tends to be more soluble (Terry et al., 2001). Both the extent of tumour differentiation as well as the site of tumour origin did not vary in relation to dietary fibre consumption from any food source.

The fibre component of fruit and vegetables provides protection against carcinogens. This is done by decreasing the concentration of toxins within faeces by means of bulking, ultimately diminishing the transit time of carcinogenic contents within the colon (Burkitt 1971). This in turn limits the generation of secondary bile acids, preventing the production of reactive oxygen species (ROS). (Young et al., 2005). It also has a regulatory effect over metabolism as well as insulin sensitivity, and so is considered to be associated with the prognosis of CRC (Brown and Meyerhardt 2016). Insulin markers, inflammation and hyperinsulinemia have shown to aggravate CRC prognosis, potentially resulting in recurrence and even death. (Cespedes Feliciano et al., 2016; Volkova et al., 2011). Therefore, increasing fibre intake through vegetables and fruit can reduce carcinogenic traits and improve CRC prognosis (Song et al., 2018).

Fibre reduces the risk of CRC mainly through fermentation, by producing anti-tumorigenic short-chain fatty acids such as butyrate, acetate and propionate, via gut microbiota (Bultman 2014; Encarnacao et al., 2015). Butyrate is a crucial source of energy for normal colonic enterocytes, stimulating the production of ROS and creating an oxidative environment (Kolar et al., 2011). However, it is used to a lesser extent in tumorigenic cells. Butyrate ends up accumulating in the nucleus of these cancerous cells, hindering the enzyme histone deacetylase and ultimately altering gene expression in relation to angiogenesis, tumour cell growth and metastasis (Encarnacao et al., 2015). Inhibition of this enzyme also gives butyrate the ability to trigger apoptosis within cancerous cells, stimulating the extrinsic death pathway (Donohoe et al., 2012). Therefore, butyrate and other compounds produced from fibre by fermentation can act as chemotherapeutic agents with respect to CRC (Bras-Gonçalves et al., 2001). Unfortunately, it is still unclear as to what point in carcinogenesis does fibre exert its anti-tumorigenic properties.

Fibre's protective traits are more significant with increased consumption of processed meat (Kunzmann et al., 2015). This results in a reduced exposure of the colon to carcinogens found in processed meat, such as N-nitrosis compounds (NOCs) (Santarelli et al., 2008). Increased processed meat intake augments the risk and development of CRC. Therefore, one can promote consumption of fibre to reduce the risk induced by processed meat. Other lifestyle factors unrelated to diet, like

smoking, can also alter the effect of dietary fibre on CRC risk (Botteri et al., 2008 as cited by Fu et al., 2013). The inverse relationship of fibre and CRC risk is generally stronger in smokers compared to non-smokers. However, smoking intensity is not a determining factor in this association (Fu et al., 2013). Fibre is able to dilute the concentration of carcinogens derived from cigarette smoke in faeces, thus diminishing the degree of contact of such carcinogens with the lumen of the colon (Lipkin et al., 1999 as cited by Fu et al., 2013). Ultimately, cigarette smoking increases the chances of developing CRC, but the extent to which it can be induced is diminished when coupled with an increase in dietary fibre.

The Colour of Fruit and Vegetables and its Influence on Colorectal Cancer

An increase in both fruit and vegetable consumption tends to decrease the risk of CRC. A stronger association exists with respect to raw vegetables in comparison to cooked vegetables, due to a lack of nutrient breakdown (Link and Potter 2004 as cited by Lee et al., 2017). In women, an inverse relationship has been recorded between CRC risk and red, green and white fruit and vegetables. The same applies for males, with the exception of yellow and orange fruit and vegetables, such as carrots, pumpkin and citrus fruits, which promote the development of CRC (Lee et al., 2017). Green fruit and vegetables possess the advantageous property of high concentrations of pro-apoptotic substances such as indole, folate, sulforphane, and lutein. They inhibit tumour cell growth and reduce cell damage (Frydoonfar et al., 2004; Nishikawa et al., 2010).

White fruit and vegetables contain different phytochemicals, all of which exert anti-tumorigenic properties. Examples include saponins present in bulb vegetables such as garlic; glucans found in mushrooms; and polysaccharides in apples. These compounds are all anti-oxidants and can decrease the likelihood of DNA damage (Li et al., 2015). Many studies on apples show a strong inverse association or no association at all with CRC risk (Jedrychowski and Maugeri 2009). Studies have also proven that garlic has the potential to promote apoptosis, whilst inhibiting progression of the cell cycle and formation of DNA adducts. However, results have shown to be inconsistent and overall conclusions have been made that garlic does not have a significantly established relationship with reduced CRC risk. (Hu et al., 2014). Citrus fruits form part of the yellow and orange fruit and vegetables group, and were found to lower the chances of CRC development in women (Levi et al., 1999 as cited by Lee et al., 2017).

They are highly rich in carotene, which regulates proliferation and metastasis of tumour cells. Similar to white fruit and vegetables, they also have anti-oxidant properties which can hinder CRC development (Liu 2004; Reczek and Chandel 2015). However, consumption of yellow fruit and vegetables can have a pro-cancerous effect on males, with respect to CRC development (Lee et al., 2017). Ginger, however, is an exception to this group. Fresh extraction of ginger root contains gingerol, which is known to hinder progression of CRC in humans due to its ability to inhibit HCT116, a human colon cancer cell line (Zick et al., 2015; Bode 2003). However, rotting ginger contains safrole, a classified carcinogen shown to promote CRC in studies conducted on rodents (Long et al., 1963 as cited by Lee et al., 2017).

Overall, fruit and vegetable consumption tend to decrease CRC risk, with the exception of the yellow and orange colour group. Fibre intake from vegetables also contributes to reduced CRC risk. Therefore, fibre-based diets, containing food such as cereals, grains, fruit and vegetables, should always be promoted, especially amongst those individuals who are susceptible to the development of CRC. By implementing this type of diet, the risk of CRC development is reduced significantly in the individual and is also associated with a decreased incidence of CRC in the general population. There is still need for more research on these relationships in order to better understand the mechanisms by which CRC is induced or inhibited, and to explore potential preventative methods or treatments.

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