Protein digestibility of sorghum and maize flours and porridges as affected by gamma-irradiation

By

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DEDICATION

To My Family

My parents, Peter N. Fombang and Ruth N. Fombang

My elder brother, Emmanuel Tadoh Fombang, for his exemplary character.

My junior siblings, Kenneth, Mccpowell, Raymond, Christabel, Cyrille and Lina.

You are each adorable for different reasons.

DECLARATION

I declare that the thesis which I hereby submit for the degree PhD (Food Science) at the University of Pretoria is my own work and has not previously been submitted by me for a degree at another University or institution of higher education.

Edith Nig Fombang
July 2005

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TO GOD BE THE GLORY.

ABSTRACT

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Sorghum foods contribute significantly to the protein intake of millions of people in developing countries. One limitation to sorghum's use as a protein source is that its proteins become less digestible on wet cooking, primarily through the formation of disulphide-linked enzymatically resistant protein polymers. Irradiation of foods can modify bonds involved in stabilizing protein structure, resulting in changes in the protein. The effects of irradiating sorghum cultivars BR7 and Madjeri, and maize cultivar PAN 6043 flours under mild (10 kGy dry) and severe (50 kGy dry and 10 and 50 kGy wet) conditions, followed by cooking into porridge on the digestibility, solubility and some molecular properties of their proteins, were investigated. Pepsin and multienzyme methods of determining protein digestibility (PD) were compared.

As expected, pepsin PD of sorghum decreased more with cooking alone (12-18%) compared to maize (4%). Sorghum porridges had more disulphide-bonded prolamin dimers than maize as shown by SDS-PAGE under non-reducing conditions. However, the amounts of disulphide bonds in both porridges appeared similar. Prolamin extractability (PE) decreased more with cooking in sorghum compared to maize. There was no significant correlation between the pepsin and multienzyme methods, suggesting the latter may not simulate *in vivo* PD that has been reported to correlate positively with pepsin PD.

Mild and severe irradiation of sorghum flour before cooking alleviated somewhat the reduction in sorghum PD on cooking. Maize porridge digestibility was unaffected by prior irradiation of dry flour but decreased with irradiation of wet flour. Mild irradiation of sorghum alleviated the reduction in PD with cooking most, almost to the level of uncooked flour. The alleviation in PD coincided with alleviation in the reduction in PE. With severe irradiation, the alleviation in PE was not consistent. Pepsin PD was positively correlated with PE for sorghum BR7 ($r=0.83$, $p<0.01$) and Madjeri ($r=0.75$, $p<0.05$), but not for maize.

With increasing irradiation severity, disulphide bond concentration decreased, while free sulphydryl groups increased in sorghum porridges from irradiated compared to unirradiated flour. This suggests breakdown of disulphide bonds to free sulphydryls. SDS-PAGE under non-reducing conditions showed lower dimer concentrations in sorghum porridges from irradiated compared to unirradiated flour. Disulphide bonds in maize were not significantly affected by irradiation and cooking. Dimers in maize porridge only decreased with severe irradiation. Nitrogen solubility index (NSI) did not change significantly with irradiation and cooking in BR7, whereas in Madjeri and maize, NSI increased slightly or not at all with mild irradiation, but with severe irradiation, some decreases occurred. Albumin and globulin (AG) solubility decreased more with irradiation alone in BR7 compared to Madjeri and maize. The differences in NSI and AG solubility in BR7 with Madjeri and maize were attributed to the presence of polyphenols in BR7 that may have showed some antioxidant activity during irradiation. Sorghum and maize porridges became darker in colour with irradiation suggesting Maillard browning.

It is proposed that irradiation of sorghum flour before cooking alleviated the reduction in PD by causing a change in protein structure. Irradiation cleaved disulphide and hydrogen bonds that stabilize kafirin protein structure giving a more open protein network, exposing additional peptide bonds to proteolysis. Under severe conditions of irradiation, covalent non-disulphide bonds may be formed, and may cause closing up of the protein structure, resulting in masking of some previously exposed peptide bonds. Irradiation is a potentially useful technique that can improve protein digestibility and nutrient density of sorghum porridge, with a potential to also reduce microbial load and improve safety.

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