MAIZE PORRIDGE STARCH DIGESTIBILITY

BY

BELINDA VAN DER MERWE

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DECLARATION

I declare that the dissertation herewith submitted for the degree MSc (Agric) Food Science and Technology at the University of Pretoria, has not previously been submitted by me for a degree at any other university or institution of higher education.

BvdMerwe

ABSTRACT

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Belinda van der Merwe

Study leader: Prof. J.R.N. Taylor
Co-leader: Mrs. C. Erasmus
Department: Food Science
Degree: M.Sc. (Agric) Food Science and Technology

The incidence of diabetes mellitus is very low in rural, traditionally living South African Black people, but higher in urbanised Black people. The carbohydrate staple of rural Black people is maize porridge, but with urbanisation maize porridge is often replaced by bread. This change in carbohydrate staple could have contributed to the higher incidence of diabetes in urban Black people.

An *in vitro* method involving pre-chewing of the food followed by digestion with pepsin and α-amylase in dialysis tubing was used to determine starch digestibility. The starch digestibility of traditional stiff maize porridge made from cultivars with different endosperm hardness was compared to white wheat bread. A hydrolysis index was calculated and used to predict the glycaemic index. The effect of different preparation parameters (particle size, cooking time, hotplate and microwave cooking) on the digestibility of maize porridge was determined, as well as the microstructures of the two food products and the starch digestibilities of maize, wheat and oat flour porridges.

Maize porridge had a lower rate ($p < 0.001$) and extent ($p < 0.001$) of *in vitro* starch digestibility than bread. Possible reasons for the difference are the dense microstructure of porridge with physically enclosed starch, and the high amylose content of South African maize. Wheat flour porridge was less digestible than bread ($p < 0.001$), which showed that the nature of the heat treatment process and the presence of other ingredients (e.g. fat) could have a great effect on starch digestibility.

Wheat flour porridge and oat flour porridge had lower starch digestibilities than maize flour porridge ($p < 0.05$), which indicated that there were intrinsic differences between the starch digestibility of the endosperm material from different cereals. These differences can possibly be attributed to other endosperm constituents, gluten in wheat and β-glucans in oats.

The starch digestibility of hotplate cooked porridge was positively correlated with endosperm hardness ($p < 0.01$). This phenomenon cannot be explained in terms of differences in composition or particle size. The composition of the endosperm from different cultivars was similar. The hard cultivars had more large particles than the soft cultivars, but it was shown that reducing the particle size of maize meal to maize flour did not have a significant effect on starch digestibility.

Interestingly, both decreasing and increasing the cooking time decreased the starch digestibility of maize porridge significantly. Cooking porridge shorter probably disrupted starch granules to a lesser extent while cooking longer probably solubilised more starch, which led to the formation of more retrograded amylose during cooling. The rate and extent of starch digestibility of microwave cooked maize porridge was similar to that of hotplate cooked porridge, but the differences between cultivars were not related to endosperm hardness. This difference between the effect of microwave and conventional cooking may be due to the faster heat transfer during microwave cooking.

The mean predicted glycaemic index for maize porridge (glucose standard) was 44, which implies that maize porridge is a slow carbohydrate release food that may be useful in the dietary management of diabetes. The fact that bread is digested faster than maize porridge could be a contributing factor in the increased prevalence of diabetes in the urban compared to the rural Black South Africans.

UITTREKSEL

MIELIEPAP STYSELVERTEERBAARHEID

deur

Belinda van der Merwe

Leier: Prof. J.R.N. Taylor
Mede-leier: Mrs. C. Erasmus
Departement: Voedselwetenskap
Graad: M.Sc. (Agric) Voedselwetenskap en -tegnologie

Die voorkoms van diabetes is baie laag onder plattelandse Suid-Afrikaanse Swartmense met 'n tradisionele lewenswyse, maar hoër onder verstedelikte Swartmense. Die koolhidraat stapelvoedsel van plattelandse Swartmense is mieliepap, maar met verstedeliking word mieliepap dikwels vervang met brood. Hierdie verandering in koolhidraat stapelvoedsel kon bygedra het tot die hoër voorkoms van diabetes onder verstedelikte Swartmense.

Styselverteerbaarheid is bepaal met 'n *in vitro* metode wat begin met die kou van die monster gevolg deur vertering met pepsien en α-amilase in 'n dialise buis. Die styselverteerbaarheid van tradisionele stywe mieliepap gemaak van kultivars met verskillende endosperm hardheid is vergelyk met witbrood. 'n Hidrolise indeks is bereken en gebruik om die glukemiese indeks te voorspel. Die effek van verskillende voorbereidingsparameters (partikelgrootte, kooktyd, stoofplaat en mikrogolf kook) op die verteerbaarheid van die pap is bepaal, asook die mikrostruktuur van die twee voedselprodukte en die styselverteerbaarhede van koring- en hawermeelpap.

Mieliepap het 'n laer tempo ($p < 0.001$) en mate ($p < 0.001$) van *in vitro* styselverteerbaarheid as brood. Moontlike redes vir die verskil is die digte mikrostruktuur van mieliepap met fisies ingeslote stysel, en die hoë amilose-inhoud van Suid-Afrikaanse mielies. Koringmeelpap was minder verteerbaar as brood ($p < 0.001$), wat aandui dat die aard van die hittebehandeling en die teenwoordigheid van

ander bestanddele (bv. vet) 'n groot effek kan hê op styselverteerbaarheid. Koringmeelpap en hawermeelpap was minder verteerbaar as mieliemeelpap ($p < 0.05$) wat aandui dat daar intrinsieke verskille in verteerbaarheid tussen die endosperm materiaal van verskillende grane is. Hierdie verskille is moontlik veroorsaak deur wesentlike bestanddele van die endosperm, gluten in koring en β-glukane in hawer.

Daar was 'n positiewe korrelasie ($p < 0.01$) tussen die styselverteerbaarheid van stoofplaat gekookte mieliepap en endosperm hardheid. Hierdie verskynsel kan nie verklaar word deur verskille in samestelling of partikelgrootte nie. Die harde kultivars het meer groot parikels gehad as die sagte kultivars, maar daar is gewys dat 'n verkleining van die partikelgrootte vanaf mieliemeel na mielieblom nie 'n betekenisvolle effek op styselverteerbaarheid gehad het nie.

Interessant genoeg het beide 'n verkorting en verlenging van die kooktyd die styselverteerbaarheid van die mieliepap betekenisvol verlaag. Om die pap korter te kook het waarskynlik die styselkorrels minder ontwrig, terwyl langer kook waarskynlik meer stysel in oplossing gebring het, wat gelei het tot meer geretrogradeerde stysel gedurende afkoeling. Die tempo en mate van styselverteerbaarheid van mikrogolf gekookte mieliepap was soortgelyk aan stoofplaat gekookte mieliepap, maar die verskille tussen kultivars was nie verwant aan endosperm hardheid nie. Hierdie verskil tussen die effek van mikrogolf- en konvensionele verhitting mag verwant wees aan die vinniger hitte-oordrag gedurende mikrogolfverhitting.

Die gemiddelde voorspelde glukemiese indeks vir mieliepap (glukose standaard) was 44, wat impliseer dat mieliepap 'n kossoort is wat koolhidrate stadig vrystel. Dit kan nuttig wees in die dieetbehandeling van diabetes. Die feit dat brood vinniger verteer as mieliepap kon 'n bydraende faktor wees in die hoë voorkoms van diabetes onder verstedelikte in vergelyking met plattelandse Swart Suid-Afrikaners.

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