The Effects of Intake of Bread with Treated Corn Bran Inclusion on Postprandial Glyceamic Response

Zhimin Cui[1], Lynne Kennedy[1], Weili Li[1*]

[1]Department of Clinical Sciences and Nutrition, University of Chester, Parkgate Road, CH1 4BJ, UK.

RESEARCH

Please cite this paper as: Cui Z, Kennedy L, Li W. The effects of intake of bread with treated corn bran inclusion on postprandial glyceamic response. Journal of Food & Nutritional Sciences [2019] 1(2): 73-81.

***Corresponding Author:**

Dr. Weili Li

Department of Clinical Sciences and Nutrition, University of Chester, Parkgate Road, CH1 4BJ, UK.

E-mail w.li@chester.ac.uk

ABSTRACT

In the current study, corn bran was treated with hydrothermal processing and then incorporated into bread. The consumption of bread with inclusion of treated corn bran (TCB) and control bread (CB) on postprandial glycaemic response was investigated in a randomised crossover intervention trial with eleven healthy participants and one hyperglycaemic participant, capillary blood samples were measured at 0, 15, 30, 45, 60, 75, 90, 105 and 120 minutes after consuming the bread.

The results showed the baseline-adjusted peak value of postprandial blood glucose with consumption of CB, containing 75 g carbohydrate was 4.27 mmol/L at 60 min after meal, but with consumption of treated corn bran bread (TCBB), containing 75 g carbohydrate was 3.88 mmol/L at 45 min after meal. In addition, the postprandial blood glucose concentration with consumption of CB is consistently higher than that with the consumption of TCBB since the peak time to 120 min. However, there was no significant differences, in turn, the incremental area under the curves (IAUC) with baseline-adjusted for CB consumption is consistently higher than that of TCBB consumption, but not any significant difference either ($p>0.05$). However, it is interesting to notice that more considerable difference in rise of blood sugar at peak time and thereafter for hyperglycaemic participant between the consumptions of TCBB and CB.

In conclusion, the consumption of bread with inclusion of TCB is able to reduce the postprandial glycaemic response to a lower level compared with the consumption of CB and the more obvious difference was observed with the hyperglycaemic participant and healthy group.

Key Words: Corn bran; hydrothermal treatment; postprandial glycaemic response; Intervention trial.

Introduction

1.1 Background

Cereal bran is the by-product in cereal processing, which is rich in protein, dietary fibre and vitamins [1]. Non-starch polysaccharide is the main components of dietary fibre which corporate with protein and other components to form the cell wall materials of plants [2, 3].

With consumers paying more attention to dietary health, cereal products are becoming more and more popular. Studies have shown that cereal products promote intestinal digestion, reduce blood glucose, and reduce cholesterol and the risk cardiovascular diseases [4 - 7]. Diabetes is a chronic hyperglycaemic metabolic syndrome caused by defects in insulin secretion [6, 8]. The incidence of diabetes mellitus is increasing year by year [5]. In 1988, Jenkins et al. [9] first proposed the concept of postprandial blood glucose level. Since then, many researches have been

reported that a high fibre diet has the benefit of lowering blood sugar and improving the reduction of postprandial glucose level [10 - 12]. Even though the studies on prevention of diabetes by the consumption of foods with enriched fibre have been well documented [5, 7, 13, 14], it is still a challenge to find affordable food material for effectively reducing the post prandial glycaemic response for consumption of starch-rich foods.

In this study, corn bran was treated through hydrothermal processing and was incorporated into bread. The effects on the intake of TCBB and CB on the postprandial glycaemic response were investigated in a randomised cross-over intervention human trial. The changes in blood glucose for eleven healthy participants and one hyperglycaemic participant were measured and were compared. The results from this study were expected to provide a better understanding of the consumption of TCBB and CB on postprandial glycaemic response for both healthy participants and hyperglycaemic participant.

2. Method

Experimental Design: Figure 1 shows a flow diagram of the experimental design used in this study.

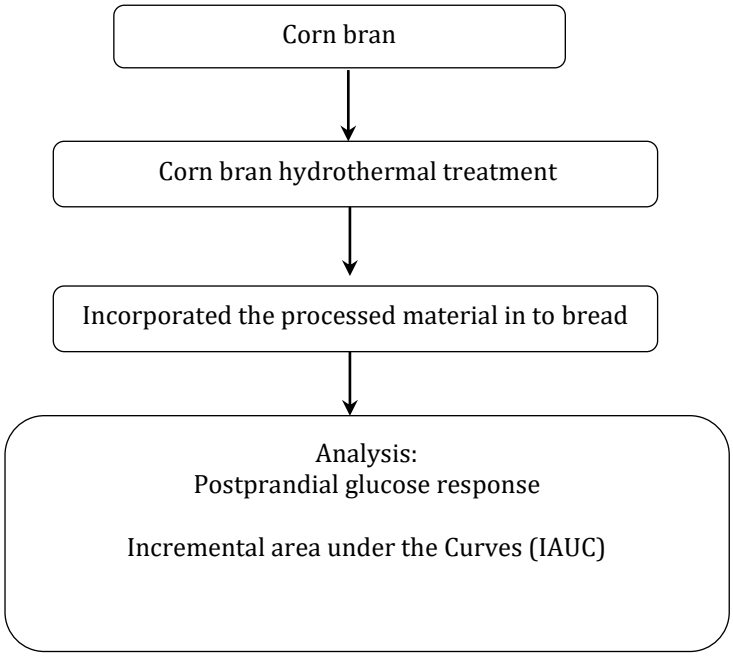

Figure 1. Experimental design for the study of treated corn bran extraction improvement in corn bran and the application in bread and postprandial glycaemic response.

2.1 Bread preparation

2.1.1 Bread recipe

Bread were prepared from the formulation, as showing in Table 1, the corn bran were processed by hydrothermal treatment.

Table 1. Bread formulation.

	CB	TCBB
	(g)	(g)
Strong flour	600	435
Yeast	15	15
Salt	10	10
Butter	30	30
Corn bran	0	165
Water 40°C	336	627
Dry weight	655	655
Total weight	991	1282

2.1.2 Bread making

Figure 2 shows the flow chart of the bread preparation procedure.

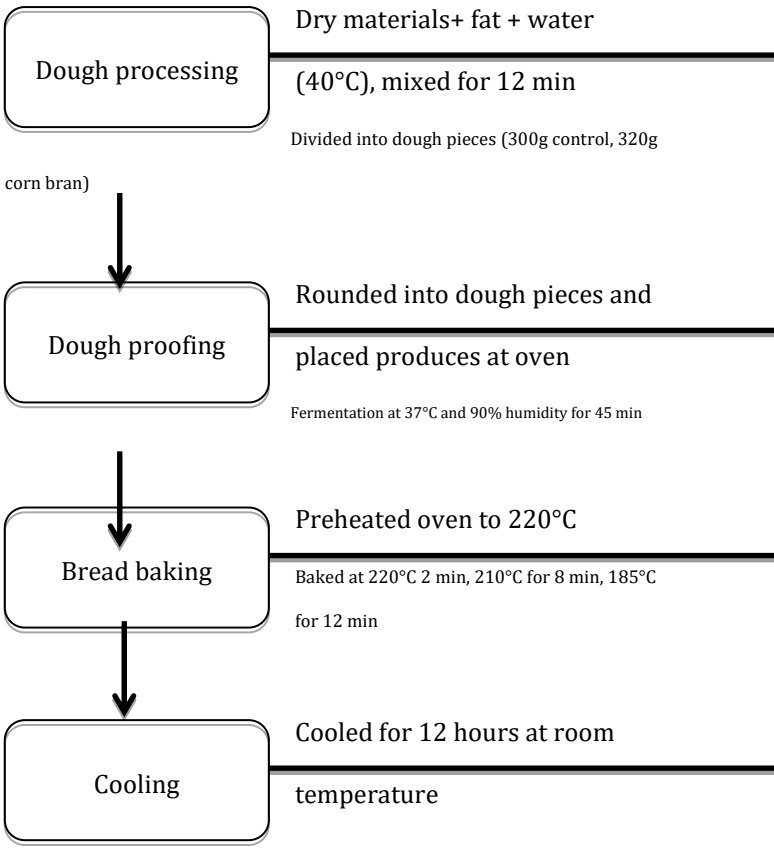

Figure 2. Bread preparation procedure.

2.2. Postprandial glycaemic response intervention trial

A randomised crossover intervention trail was conducted in 2018 at University of Chester Clinic Lab (Chester, UK). Eleven healthy and one hyperglycaemic participants over 18 year-old males and females were recruited in this study. The physical characteristics and age of participants were obtained from a questionnaire. Participants were aged between 28 and 55, eleven healthy participants fasting glucose levels ≤6.0 mmol/L and one hyperglycaemic participant fasting blood glucose (FBG) level > 7.0 mmol/L, were non-smokers, had no history of cancer or metabolic diseases and were not pregnant (if female).

In order to determine Body Mass Index (BMI), height ruler (Seca, UK) and scale (Seca, UK) measured the weight and height (without footwear) of participants respectively. The BMI was between 19 and 31 kg/m2. The ethnicity of the participants was Chinese. For each experiment, the participants were asked to fasting for 12 hours (water drinking was allowed) prior to providing blood samples. Before attending the Clinic Lab, participants were asked to abstain from alcohol and vigorous exercise for 12 hours. Each participant was required to attend two separate occasions to consume either TCBB or CB with 75g available carbohydrate.

The measurements were performed in August 2018 at the University of Chester Clinic Lab (Chester, UK). The research was approved by the Faculty of Medicine, Dentistry and Life Sciences Research Ethics Committee (FREC reference: 1459 (1429)/18/ZC/CSN, The University of Chester, 2018). The study followed University of Chester ethics process guidelines. This intervention human trial crossover test was carried out on two separate occasions, one week apart. Postprandial glucose was measured by a finger prick glucose detector device (Contour next, Parsippany, UK). Participation was voluntary, and the participants were reassured of their right to withdraw any time from the study without giving a reason. All participants were provided with both verbal and written information, and gave informed consent. Blood samples and research data were coded at the source and anonymised.

All participants were randomised to consume either the TCBB or the CB on two separate occasions. Therefore, all participants consumed either the TCBB or the CB containing75- g of carbohydrates. Capillary blood was obtained on each occasion from finger prick samples according to the standard protocol of the phlebotomy unit. Blood samples were obtained at 0, 15, 30, 45, 60, 75, 90, 105 and 120 minutes after consuming either the TCBB or CB.

Nutrition profile of TCBB and CB

Both TCBB and CB followed the bread-making recipe in Table 1. The TCBB and CB were matched for carbohydrate, protein and fat as shown in Table 2. The nutrition profile was investigated by NUTRITICS software to determine the nutrition value in both breads.

Table 2. The nutrition value TCBB and CB.

EU: RI (Labelling)	TCBB (100g)	CB (100g)
Energy (Kcal)	219kcal	268kcal
Energy (KJ)	928KJ	1133KJ
Carbohydrate (g)	42g	50g
Protein (g)	6.3g	8.5g
Fat (g)	2.9g	3.7g

2.3. Data Analysis and calculation

Glycaemic Response Calculation

Blood glucose levels were measured at 0, 15, 30, 45, 60, 75, 90, 105 and 120 minutes after consuming the bread, and the Incremental area under the curve (IAUC) was calculated by trapezoidal method. Moreover, the values that were below the FBG (baseline) value were excluded. See example curve in figure 3.

Statistical analysis

Data analysis was performed using IBM SPSS 25 Statistical software. T-test independent sample were used to compare the mean value between groups. The results were expressed as mean± standard deviation, $p < 0.05$ means significant difference.

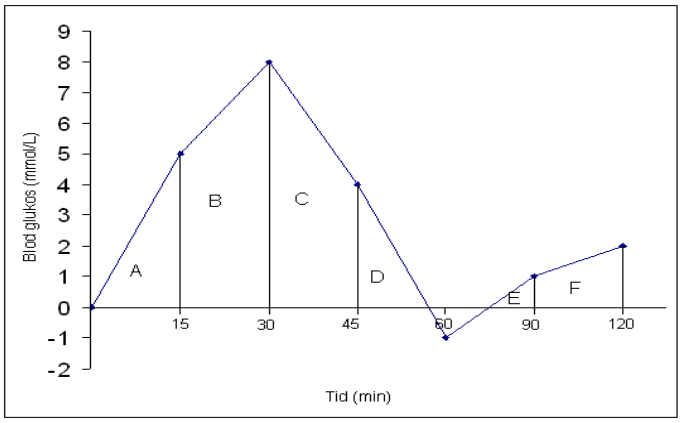

Figure 3. Example of AUC calculation.

$$\text{Area}=\sum f(x)\ 120\ 0 = \text{A+B+C+D+E+F}$$

Table 3. Participant's physical characteristics

	Age (years)	Weight (kg)	Height (m)	BMI (kg/m^2)
	Mean± S.D.	Mean± S.D.	Mean± S.D.	Mean± S.D.
Participants Pre-diabetes	40.82±8.48 39	66.48±12.63 67	1.63±0.08 1.68	25.08±3.96 23.74

3. Results

3.1 Postprandial glycaemic response intervention trial

3.1.1 Physical characteristics of participants

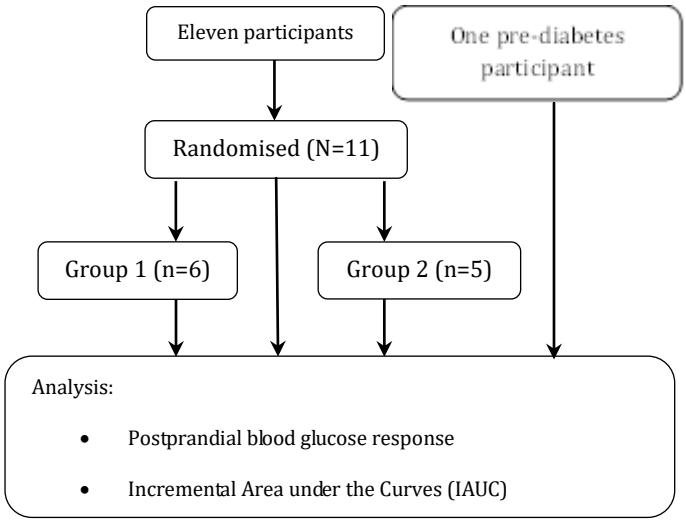

Figure 4. Scheme randomised crossover trail.

Eleven healthy participants (randomised coded as N1-N11) and one hyperglycaemic participant (coded as N12) volunteered to participate in this research (Figure 4), the physical characteristics and FBG mean value of all participants are showed in Table 3. The FBG concentration of eleven participants and one hyperglycaemic participant are reported in Table 4.

Table 4. The mean of FBG levels of eleven participants and one pre-diabetes participant.

	CB	TCBB
	Mean±S.D.	Mean±S.D.
Healthy participants FBG (mmol/L)	5.58±0.36	5.56±0.34
Pre-diabetes FBG (mmol/ L)	7.80	7.10

As Table 4 shows, the high standard deviation in age and weight mean value for participants, resulting in the majority of BMI value in the range of 21.12 to 29.04, which indicated the majority of participants in the healthy weight to overweight range.

3.1.2 Baseline-adjusted postprandial blood glucose concentration changes

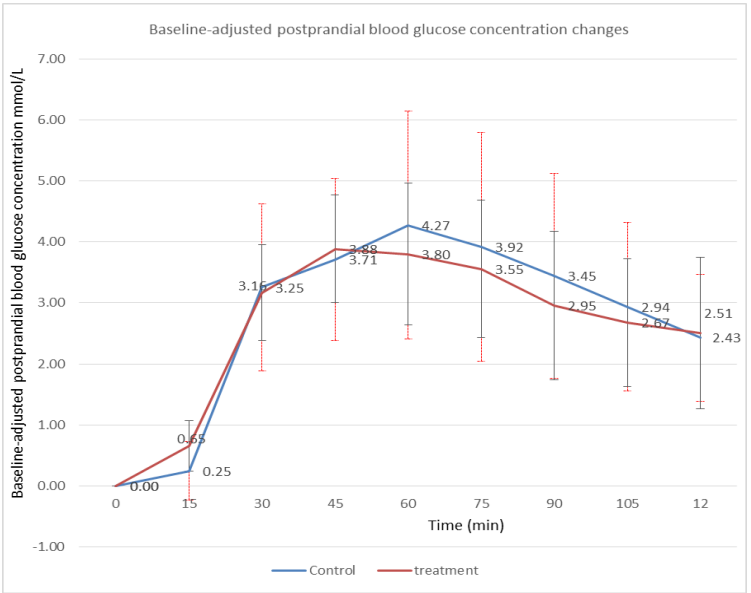

Figure 5. Baseline-adjusted blood glucose concentration throughout 120 minutes following the consumption of the TCBB and CB (P >0.05).

The changes in blood glucose concentration of participants throughout the 120 min are shown in Figure 5, the FBG was considered as baseline, the increase peak value

in postprandial blood glucose for the TCBB consumption was 45 min (3.88 mmol/L), however, it was for CB consumption was at 60 min (4.27 mmol/L). The baseline-adjusted blood glucose concentration for the consumption of TCBB was lower than that for the consumption of CB at all measurement points from 46 min to 120 min and the peak drop rate of TCBB and CB were 0.03 for the consumption of the TCBB and 0.018 for the consumption of CB. However, independent t-test analysis showed that no significant difference in baseline-adjusted blood glucose concentration between the intake of TCBB and CB ($p > 0.05$).

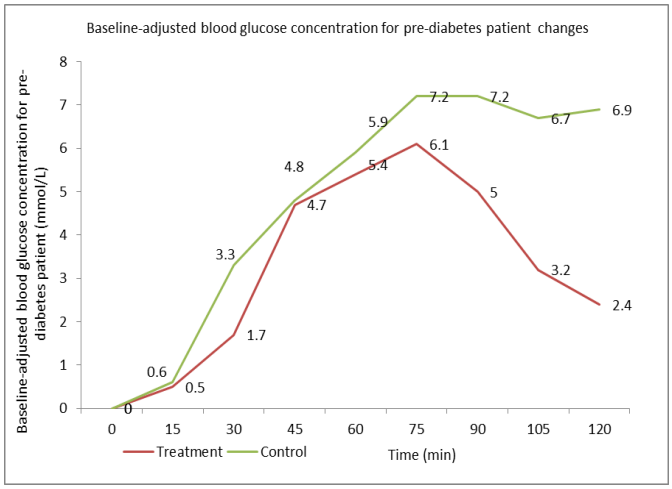

Figure 6. Changes in blood glucose concentration throughout 120 minutes following the consumption of the TCBB and CB for pre-diabetes patient.

Figure 6 shows the baseline-adjusted blood glucose concentration for hyperglycaemic participant throughout 120 minutes. The blood glucose concentration peak value for the consumption of the TCBB was 6.1 mmol/L, however, for CB consumption, it was 7.2mmol/L. From 75 min to 120 min, the blood glucose concentration for the consumption of TCBB rapidly decreased and it dropped to the similar level with those for healthy participants at 120min. Whilst, for the consumption of CB, the blood glucose concentration remained consistent level without obvious decrease. Moreover, the peak value of hyperglycaemic participant both with TCBB and CB were higher than that of healthy participants. As only one hyperglycaemic participant attended this study, the data is not analysed statistically.

With the combination of Figure 4 and Figure 5, the baseline-adjusted blood glucose peak value is 4.27 mmol/L and 7.2 mmol/L respectively for healthy participants and hyperglycaemic participant after the consumption CB. However, it is 3.88 mmol/L and 6.1 mmol/L for healthy range participants and hyperglycaemic participant after the consumption TCBB, which are lower than that of healthy participants and hyperglycaemic participant after the consumption CB. For the healthy participants, the postprandial blood glucose concentration with consumption of TCBB is consistently lower than that with CB after the peak time, but not statistically different. For the hyperglycaemic participant, the peak value of blood glucose concentration for the intake of TCBB is much more lower in comparison with the consumption of CB, showing a sharp decrease after the peak time, meanwhile no considerable decrease was observed with the consumption of CB, demonstrating the intake of TCBB was more effectively to reduce the blood glucose concentration for hyperglycaemic participant in comparison with TCBB consumption healthy participants. It is interesting to notice that the increase in baseline-adjusted blood glucose concentration at 120 min of testing time for hyperglycaemic participant was at the same level as that for the healthy participants.

3.1.3. Incremental Area under the Curves (IAUC)

The baseline adjusted IAUC for consumption of TCBB and CB is shown in Table. 5. The IAUC of blood glucose concentration for consumption of TCBB is slightly lower than that of CB for healthy participants, but there were no significant differences ($p > 0.05$). For hyperglycaemic participant, both the intake of TCBB and CB caused a greater increase in blood glucose peak value and IAUC than any one for healthy participants, but more obvious reduction in IAUC was found with the consumption of TCBB for hyperglycaemic participant, showing the consumption of TCBB is able to more effectively to reduce the post-prandial glycaemic response for hyperglycaemic than for healthy people.

Table 5. Mean values of IAUC of the TCBB and CB, participant code 1-11 are healthy participant, code 12 is pre-diabetes participant.

	IAUC	
Participant code	CB	TCBB
1	418	455.1
2	340.1	432.7
3	242.8	382.75
4	267.45	336.35
5	429.3	390.55
6	551.75	461.55
7	175.65	232.9
8	607.5	302
9	344.1	281.1
10	185	168.3
11	268.6	287.85
Average ±S.D.	348.20±141.62	339.20±94.65
12	576.6	408.25

4. Discussion

The corn bran applied in this study was treated by hydrothermal process. Many researchers demonstrated that the hydrothermal treatments were able to increase the water solubility of arabinoxylans (AXs) from cereal bran (58%- 71%) [15-18].

According to the results of current study, the change in postprandial blood glucose concentration at and after the peak time to the end of testing (120 min) for the healthy participants with consumption of TCBB is consistently lower than that with the intake of CB. Even though no significant difference in postprandial blood glucose concentrations between the consumption of TCBB and CB for healthy participants, it still demonstrates that the intake of TCBB has the effect on the reduction of the blood glucose rise in comparison with the intake of CB, which is consistent with the results from study conducted by Mo hlig et al. (2005) [19]. He reported that after the intake of AXs-rich meal, glucose response was also not significantly different in subjects with normal glucose regulation (p= 0.367), and the insulin responses after an AX-enriched breakfast showed only a tendency towards lower values (p= 0.065). His results shown that AXs-rich bread delayed the absorption of glucose and make the peak postprandial blood glucose shift more gently to later time in comparison with control white bread, but does not affect the total absorption of glucose. However, in the current study, no any delay in the peak value of glucose absorption with the intake of TCBB. The peak value of blood glucose for the intake of TCBB was lower than that for CB, which indicates the TCBB release less glucose into the blood stream in comparison with CB. For the hyperglycaemic participant, the peak value for the intake of TCBB is much lower in comparison with CB, and the blood glucose concentration with consumption of TCBB showed more considerable decrease after the peak value compared with that for the intake of CB, which was almost maintained at same level up to 120 min. It is interesting to notice that the adjusted baseline postprandial glycaemic response of hyperglycaemic participant with the intake of TCBB dropped to the similar level to that for healthy participants at 120min. The study results revealed that the consumption of TCBB has more significant impact on the hyperglycaemic participant than on the healthy participants in terms of reducing postprandial glycaemic response

Burton et al. [20] reported that contain 50g carbohydrate were considered as ideally consuming meal. In 1998, the Food Agriculture Organization defined: “The glycaemic index is expressed as the incremental area under the blood glucose response curve of a 50g carbohydrate portion of a test food expressed as a percent of the response to the same amount of carbohydrate from a standard food taken by the same subject.” In many studies, it has been found that with 50g carbohydrate the peak of blood glucose response was at 30 min [20, 21]. In the current study, the participant consumed 75 g carbohydrates either of TCBB or of CB in order to explore the glucose absorption with a large amount carbohydrate intake, which caused the blood glucose peak time shifted to 45min for TCBB and 60min for CB for healthy participants and 75 min for hyperglycaemic participant for both CB and TCBB.

Vogel et al. [22] investigated functionalities of AXs gel, which extracted from corn bran by alkaline treatment. The results showed that the postprandial glucose response of intragastrically administered rats has decreased 5-9%. As previously mentioned, the corn bran treated with hydrothermal process have more the water soluble AXs [15 - 18]. As it was incorporated into TCBB, water soluble AXs likely modulate the glucose release and thus reduce the postprandial glucose response for both for healthy and hyperglycaemic participants.

For the aspects of human health and management implementations, the results of current study research further confirmed that AXs-rich food is able to reduce the postprandial glycaemic response, in turn improve glucose tolerance for healthy participants, therefore the AXs demonstrated a certain blood sugar regulating function for healthy people, which potentially contribute to less variation in blood sugar after AXs-rich meal. Furthermore, it is likely that AXs-enriched foods contribute to more significant reduction of postprandial glucose response for hyperglycaemic patients, which in turn significantly reduce the risk of diabetes. The European Food Safety Authority (EFSA) approved the consumption of wheat endosperm AXs as part of a food with no less 4.8% per 100g available carbohydrate contributes to a reduction of the blood glucose rise after that meal based on scientific review in 2011 [23]. In 2018, Kellow et al. has reviewed eight publications, the results of eight publications show the meal with added AXs had significant utility on participant with type 2 diabetes and metabolic disturbance, but there was no significant difference for healthy participants, which are consistent with the results of current study [24].

5. Conclusion

For health participants, the results showed that the baseline-adjusted value of postprandial blood glucose at and after peak time with consumption of CB is consistently higher than that with the consumption of TCBB, but there was no significant differences ($p>0.05$). The baseline-adjusted IAUC for consumption of CB is consistently higher than that for the consumption of TCBB, but not significantly either ($p>0.05$). More considerable difference in postprandial glycaemic response from peak time to end of testing was noted for hyperglycaemic participant with the consumptions of TCBB and that of CB.

The results in this study demonstrated that TCB meal (AXs-rich meal) reduced blood glucose response after meal and improved glucose tolerance for healthy people, showing blood glucose regulating function for healthy people. Furthermore, it contributed to more obvious reduction of blood glucose response after meal for hyperglycaemic participant. This research might also provide the information for hyperglycaemic control. However, the mechanism of treated corn bran in control of hyperglycaemic issues remains unclear and further research in this area should be carried out in the future.

Conflicts of interest

Authors declare no conflicts of interest.

Acknowledgements

Sources for funding were obtained from the university department of Clinical Sciences and Nutrition faculty research funds, University of Chester.

References

1. Salden BN, Troost FJ, Wilms E, Truchado P, Vilchez-Vargas R, et al; Reinforcement of intestinal epithelial barrier by arabinoxylans in overweight and obese subjects: A randomized controlled trial: Arabinoxylans in gut barrier. Clin Nutr, 2018. 37(2): p. 471-480.

2. Guillermo Nino-Medina, Elizabeth Carvajal-Millan, Agustín Rascon-Chu, Jorge A. Marquez-Escalante, Victor GuerreroErika, et al; Feruloylated arabinoxylans and arabinoxylan gels: structure, sources and applications. Phytochemistry Reviews, 2009. 9: p. 111-120.

3. Penny Comino, Helen Collins, Jelle Lahnstein, Michael J, Gidley Effects of diverse food processing conditions on the structure and solubility of wheat, barley and rye endosperm dietary fibre. Journal of Food Engineering, 2016. 169: p. 228-237.

4. Mateo Anson N, Hemery YM, Bast A, Haenen GR, Optimizing the bioactive potential of wheat bran by processing. Food Funct, 2012. 3(4): p. 362-375.

5. Knudsen, K. E. B., Hartvigsen, M.L., Hedemann, M. S., Hermansen, K. Chapter 8: Mechanisms Whereby Whole Grain Cereals Modulate the Prevention of Type 2 Diabetes. Molecular Nutrition and Diabetes, 2016. Academic Press.

6. Fadel A, Mahmoud AM, Ashworth JJ, Li W, Ng YL, Plunkett A, Health-related effects and improving extractability of cereal arabinoxylans. Int J Biol Macromol, 2018. 109: p. 819-831.

7. Dikeman CL, Fahey GC, Viscosity as Related to Dietary Fiber: A Review. Crit Rev Food Sci Nutr, 2006. 46(8): p. 649-663.

8. Evangelou E, Ntritsos G, Chondrogiorgi M, Kavvoura FK, Hernández AF, Ntzani EE, Tzoulaki I, Exposure to pesticides and diabetes: A systematic review and meta-analysis. Environ Int, 2016. 91: p. 60-68.

9. D. J. Jenkins, V. Wesson, T. M. Wolever, A. L. Jenkins, J. Kalmusky, S. Guidici, A. Csima, R. G. et al; Wholemeal versus wholegrain breads: proportion of whole or cracked grain and the glycaemic response. BMJ, 1988. 297(6654): p. 958-960.

10. Dikeman CL, Fahey GC, Viscosity as Related to Dietary Fiber: A Review. Crit Rev Food Sci Nutr, 2006. 46(8): p. 649-663.

11. Gianluca Giuberti, Antonio Gallo, Maurizio Moschini, Francesco Masoero, New insight into the role of resistant starch in pig nutrition. Animal Feed Science and Technology, 2015. 201: p. 1-13.

12. Marciani L, Gowland PA, Spiller RC, Manoj P, Moore RJ, Young P, Fillery-Travis AJ, Effect of meal viscosity and nutrients on satiety, intragastric dilution, and emptying assessed by MRI. Am J Physiol Gastrointest Liver Physiol, 2001. 280(6): p. G1227-1233.

13. Gianluca Giuberti, Antonio Gallo, Maurizio Moschini, Francesco Masoero, New insight into the role of resistant starch in pig nutrition. Animal Feed Science and Technology, 2015. 201: p. 1-13.

14. Marciani L, Gowland PA, Spiller RC, Manoj P, Moore RJ, Young P, Fillery-Travis AJ, Effect of meal viscosity and nutrients on satiety, intragastric dilution, and emptying assessed by MRI. Am J Physiol Gastrointest Liver Physiol, 2001. 280(6): p. G1227-1233.

15. Debora Nabarlatz, Xavier Farriol, Daniel Montane, Kinetic Modeling of the Autohydrolysis of Lignocellulosic Biomass for the Production of Hemicellulose-Derived Oligosaccharides. Industrial & Engineering Chemistry Research, 2004. 43(15): p. 4124-4131.

16. B.S.Dien, X.-L.LiL.B.Iten, D.B.Jordan, N.N.Nichols, P.J.O'Bryan, M.A.Cotta, Enzymatic saccharification of hot-water pretreated corn fiber for production of monosaccharides. Enzyme and Microbial Technology, 2006. 39(5): p. 1137-1144.

17. Gil Garrote, Herminia Dominguez, Juan Carlos Parajo, Kinetic modelling of corncob autohydrolysis. Process Biochemistry, 2001. 36(6): p. 571-578.

18. Reisinger M, Tirpanalan O, Prückler M, Huber F, Kneifel W, Novalin S, Wheat bran biorefinery – A detailed investigation on hydrothermal and enzymatic treatment. Bioresou Technol, 2013. 144: p.179-185.

19. M Möhlig M, Koebnick C, Weickert MO, Lueder W, Otto B, et al; Arabinoxylan-enriched meal increases serum ghrelin levels in healthy humans. Horm Metab Res, 2005. 37 (5): p. 303.

20. Burton JP, Cowley S, Simon RR, McKinney J, Wescombe PA, Tagg JR, Evaluation of safety and human tolerance of the oral probiotic streptococcus salivarius K12: A randomized placebo-controlled, double-blind study. Food Chem Toxicol, 2011. 49(9): p. 23562364.

21. Sen K, Singhania P. R, Glycemic and insulinemic responses to carbohydrate rich whole foods. J Food Sci Technol, 2011. 51(2): p. 347–352.

22. Vogel B, Gallaher D. DQQQ, Bunzel M, Influence of Cross-Linked Arabinoxylans on the Postprandial Blood Glucose Response in Rats. J Agric Food Chem, 2012. 60(15): p. 3847-3852.

23. Scientific Opinion on the substantiation of health claims related to arabinoxylan produced from wheat endosperm and reduction of post-prandial glycaemic responses (ID 830) pursuant to Article 13(1) of Regulation (EC) No 1924/2006. EFSA Journal, 2011. 9(6): 2205.

24. Kellow N. J, Walker K. Z. Authorised EU health claim for arabinoxylan. Foods, Nutrients and Food Ingredients with Authorised EU Health Claims. 2018. 3: p201-218.

PEER REVIEW

Not commissioned. Externally peer reviewed.