



Impact of Natural Hydrocolloids Addition on the Physicochemical, Antioxidant and Digestive Enzymes Inhibitory Properties of *Sorghum bicolor* flour

Irondi E.A., Bankole A.O., Imam Y.T., Oyelegbin M.O., Pelewura O.P., Busari T.M.

Department of Biochemistry, Kwara State University, Malete, P.M.B. 1530, Ilorin, Nigeria

*Correspondence: emmanuel.ironi@kwasu.edu.ng; Tel.: +2348034870657



INTRODUCTION

The sustainability of using wheat flour for baked foods is threatened by its high cost, especially in countries that depend on imported wheat for their bakery industry. As recently reported by Dongyu (2022), the price of wheat increased by 31% in 2021 due to COVID-19-related port disruptions, high costs of shipping, and increased demand. Further, the use of modified hydrocolloids as gluten replacement in gluten-free food products by the food industry is associated with a higher production cost, and loss of some healthful properties. These challenges necessitate finding alternatives to wheat flour in baked food products.

Sorghum bicolor (Sorghum) is a promising functional ingredient for the development of functional food products, due to its outstanding nutritional properties and bioactive compounds (Batariuc et al., 2021). It is the fifth most important cereal after rice, wheat, maize, and barley. Furthermore, it is a gluten-free cereal and this makes it suitable for making food products for individuals that are susceptible to gluten allergy (Ofosu et al., 2020). Thus, it could be a viable staple for improved nutrition and achieving food security. Hence, the impact of the addition of two natural hydrocolloid-rich flours (*Brachytegia eurycoma* and *Detarium microcarpum*) on the physicochemical, antioxidant, and digestive enzymes inhibitory properties of red *Sorghum bicolor* flour was evaluated in this study.

METHODOLOGY

The samples [red *Sorghum bicolor* (SB), *Brachystegia eurycoma* (BE), *Detarium microcarpum* (DM) seeds, refined *Triticum aestivum* flour (TA), and Sodium carboxymethyl cellulose (SCMC), 500 g each] were obtained from a market in Ilorin, Kwara State, Nigeria. The seed samples were sorted, ground into flour. The BE, DM, and SCMC were incorporated into the SB flour at 2 and 4% proportions, with the refined TA (wheat) flour serving as a control. Each sample packed hermetically in an opaque plastic container, and stored at 4°C during analysis.

The bioactive constituents (total phenolics, tannin, and total flavonoids); antioxidant activities (reducing power, DPPH•, and ABTS•+ scavenging), physicochemical properties (starch, amylose, amylopectin, and pasting properties); digestive enzymes (pancreatic lipase, α-amylase, and α-glucosidase) inhibitory properties of the samples were evaluated. Results of the triplicate test were analyzed using one-way ANOVA, followed by an LSD test at 95% confidence interval.

Table 1: Bioactive constituents levels of flour samples

Sample	Total phenolics (GAE mg/g)	Tannins (TAE mg/g)	Total flavonoids (QE mg/g)
SB	11.50±0.16 ^a	15.89±1.15 ^a	4.71±0.11 ^a
TA	0.77±0.01 ⁱ	0.85±0.04 ^k	0.14±0.01 ^k
BE	6.68±0.17 ^g	7.75±0.30 ^g	1.17±0.5 ^j
DM	2.81±0.13 ^k	3.13±0.35 ^j	0.17±0.00 ^j
SCMC	0.69±0.21 ⁱ	0.77±0.35 ^k	0.05±0.01 ^k
SB+SCMC (98:2)	8.82±0.06 ^e	12.53±0.19 ^e	4.00±0.14 ^d
SB+SCMC (96:4)	7.39±0.09 ^f	10.59±0.19 ^f	3.84±0.28 ^e
SB+BE (98:2)	10.97±0.20 ^b	14.71±0.58 ^b	4.35±0.04 ^b
SB+BE (96:4)	9.33±0.09 ^d	12.99±0.19 ^d	4.01±0.01 ^d
SB+DM (98:2)	9.67±0.09 ^c	13.82±0.29 ^c	4.18±0.21 ^c
SF+DM (96:4)	8.88±0.11 ^e	12.45±0.19 ^d	3.97±0.21 ^d

Data are the mean values ± SD of triplicate determinations. Data having different lowercase superscript letters along the same column differ significantly ($p < 0.05$). SB, red *Sorghum bicolor* flour; TA, refined *Triticum aestivum* (wheat) flour; BE, *Brachytegia eurycoma* flour; DM, *Detarium microcarpum*; SCMC, sodium carboxymethyl cellulose

Table 2: Antioxidant activities of the flour samples

Sample	Reducing power (GAE mg/g)	ABTS** (TE μM/g)	DPPH* SC ₅₀ (mg/mL)
SB	16.42±0.13 ^a	2160.33±2.67 ^a	227.10±0.47 ^m
TA	2.14±0.01 ^u	237.10±6.02 ^p	686.96±3.75 ^b
BE	12.19±0.11 ^b	1146.20±4.00 ^m	330.47±1.73 ^e
DM	3.14±0.42 ^t	512.25±4.00 ^o	547.42±4.75 ^c
SCMC	1.72±0.04 ^v	119.88±1.99 ^q	733.95±8.51 ^a
SB+SCMC (98:2)	14.87±0.09 ^d	2055.82±5.35 ^j	248.71±1.13 ^k
SB+SCMC (96:4)	13.03±0.09 ^f	1994.30±2.67 ⁱ	259.06±1.85 ^j
SB+BE (98:2)	16.00±0.09 ^b	2118.29±2.68 ^d	236.50±1.03 ⁱ
SB+BE (96:4)	15.26±0.05 ^k	2059.18±2.66 ^c	245.02±0.76 ^k
SB+DM (98:2)	15.55±0.09 ^c	2080.43±2.68 ^c	243.60±1.63 ^k
SF+DM (96:4)	14.81±0.05 ^d	2025.33±2.66 ^c	253.01±0.82 ^{ij}

Data are the mean values ± SD of triplicate determinations. Data having different lowercase superscript letters along the same column differ significantly ($p < 0.05$). SB, red *Sorghum bicolor* flour; TA, refined *Triticum aestivum* (wheat) flour; BE, *Brachytegia eurycoma* flour; DM, *Detarium microcarpum*; SCMC, sodium carboxymethyl cellulose

Table 3: Startch, Amylose, Amylopectin contents of the flour samples

Sample/Parameter	Starch (g/100g)	Amylose (g/100g)	Amylopectin (g/100g)	Amylose/Amylopectin
SB	79.93±0.29 ^a	17.49±0.27 ^d	82.51±0.27 ^e	0.21±0.00 ^e
TA	76.76±0.28 ^b	12.25±0.13 ^g	87.75±0.13 ^b	0.14±0.00 ^f
BE	34.37±0.21 ⁱ	1.65±0.28 ^h	98.36±0.28 ^a	0.01±0.01 ⁱ
DMF	37.13±0.33 ^k	0.94±0.00 ^h	99.06±0.00 ^a	0.01±0.00 ^j
SCMC	40.46±0.29 ^j	1.22±0.21 ^h	98.79±0.21 ^a	0.01±0.00 ^j
SB+SCMC (98:2)	69.97±0.04 ^e	17.57±0.07 ^d	82.43±0.07 ^e	0.21±0.00 ^e
SB+SCMC (96:4)	63.95±028 ^b	16.07±0.41 ^f	83.93±0.41 ^{cd}	0.19±0.01 ^h
SB+BE (98:2)	75.78±0.43 ^b	16.79±0.21 ^d	83.20±0.21 ^{de}	0.20±0.00 ^e
SB+BE (96:4)	61.51±0.29 ^f	16.17±0.27 ^f	83.83±0.27 ^{cd}	0.19±0.01 ^g
SB+DM (98:2)	69.07±0.34 ^f	16.27±0.13 ^f	83.72±1.34 ^{cd}	0.19±0.0 ^g
SF+DM (96:4)	64.58±0.14 ^b	15.52±0.40 ^f	84.48±0.40 ^c	0.18±0.01 ^f

Data are the mean values ± SD of triplicate determinations. Data having different lowercase superscript letters along the same column differ significantly ($p < 0.05$). SB, red *Sorghum bicolor* flour; TA, refined *Triticum aestivum* (wheat) flour; BE, *Brachytegia eurycoma* flour; DM, *Detarium microcarpum*; SCMC, sodium carboxymethyl cellulose

Table 4: Pasting properties of flour samples

Sample/Parameter	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Set-back viscosity (RVU)	Peak time (min)	Pasting temp. (°C)
SB	63.78±0.16 ^a	59.94±0.16 ^a	3.84±0.01 ^k	185.62±0.18 ^m	125.68±0.21 ⁱ	5.23±0.04 ^a	88.17±0.11 ^d
TA	230.61±0.62 ^d	110.01±0.02 ^e	120.59±0.60 ^b	220.77±0.38 ^j	110.75±0.36 ⁿ	6.01±0.01 ^b	70.17±0.11 ^k
BE	675.79±0.41 ^b	443.76±0.33 ^c	232.02±0.74 ^a	1091.20±0.83 ^b	647.44±0.55 ^a	7.00±0.01 ^a	85.75±0.14 ^f
DMF	524.16±1.18 ^c	500.26±0.97 ^b	23.90±0.21 ⁿ	860.11±1.22 ^c	359.84±0.25 ^c	6.91±0.02 ^a	50.22±0.35 ^j
SCMC	782.54±0.76 ^a	728.39±0.62 ^a	54.15±0.14 ^c	1170.35±0.81 ^a	441.95±0.18 ^b	6.77±0.34 ^b	50.12±0.35 ^j
SB+SCMC (98:2)	68.45±0.28 ⁱ	66.01±0.26 ^p	2.43±0.02 ^m	135.30±0.17 ^p	69.28±0.42 ^p	6.45±0.07 ^c	89.60±0.71 ^c
SB+SCMC (96:4)	79.35±0.45 ^f	75.02±0.56 ^j	4.32±0.11 ^k	134.04±0.76 ^p	59.02±0.21 ^q	6.79±0.01 ^b	93.65±0.71 ^b
SB+BE (98:2)	70.02±0.03 ^h	67.11±0.04 ^o	2.91±0.01 ^l	183.15±0.69 ^a	116.04±0.65 ^m	6.91±0.02 ^a	87.27±0.04 ^e
SB+BE (96:4)	72.56±0.33 ^h	71.97±0.32 ^m	0.59±0.01 ⁿ	189.60±0.74 ^e	117.62±0.42 ^j	6.33±0.09 ^d	87.35±0.71 ^e
SB+DM (98:2)	79.88±0.19 ^f	76.86±0.16 ^k	3.02±0.03 ^j	199.91±0.12 ^f	123.05±0.28 ^k	5.71±0.02 ^f	87.15±0.14 ^e
SF+DM (96:4)	92.35±0.45 ^e	90.11±0.55 ^j	2.23±0.09 ^m	223.77±0.21 ^f	133.66±0.34 ⁱ	6.16±0.13 ^f	85.55±0.71 ^g

Data are the mean values ± SD of triplicate determinations. Data having different lowercase superscript letters along the same column differ significantly ($p < 0.05$). SB, red *Sorghum bicolor* flour; TA, refined *Triticum aestivum* (wheat) flour; BE, *Brachytegia eurycoma* flour; DM, *Detarium microcarpum*; SCMC, sodium carboxymethyl cellulose

Table 5: Digestive enzymes (pancreatic lipase, α-amylase and α-glucosidase) inhibitory activities of flour samples

Parameter	Pancreatic lipase IC ₅₀ (μg/mL)	Alpha-amylase IC ₅₀ (μg/mL)	Alpha-glucosidase IC ₅₀ (μg/mL)
SB	66.11±0.41 ⁱ	122.83±0.35 ^b	90.35±0.64 ⁱ
TA	476.06±14.03 ^b	1144.20±15.41 ^b	809.97±10.32 ^b
BE	111.70±1.16 ^d	149.98±0.79 ^{def}	123.83±0.97 ^d
DM	214.51±4.27 ^c	671.30±15.91 ^c	531.97±4.45 ^c
SCMC	625.89±12.13 ^a	1483.31±25.90 ^a	966.77±14.70 ^a
SB+SCMC (98:2)	69.96±00.45 ^{hi}	129.87±0.59 ^{gh}	96.56±0.15 ^{hi}
SB+SCMC (96:4)	73.21±0.67 ^{hi}	135.28±0.86 ^{efgh}	99.89±0.62 ^{ghhi}
SB+BE (98:2)	67.08±0.42 ⁱ	124.88±037 ^h	93.84±0.28 ^{hi}
SB+BE (96:4)	69.43±0.30 ^{hi}	126.32±0.18 ^{gh}	95.94±0.15 ^{hi}
SB+DM (98:2)	69.01±0.60 ⁱ	126.45±0.76 ^{gh}	95.84±0.57 ^{hi}
SF+DM (96:4)	71.15±0.32 ^{hi}	127.53±0.76 ^{gh}	97.29±0.30 ^{ghhi}

Data are the mean values ± SD of triplicate determinations. Data having different lowercase superscript letters along the same column differ significantly ($p < 0.05$). SB, wholemeal red *Sorghum bicolor* flour; TA, refined *Triticum aestivum* (wheat) flour; BE, *Brachytegia eurycoma* flour; DM, *Detarium microcarpum*; SCMC, sodium carboxymethyl cellulose

CONCLUSIONS

The starch and amylose contents of *Sorghum bicolor* flour decreased, while its amylopectin content, amylose-amylopectin ratio and pasting properties significantly increased ($p < 0.05$) as the proportions of the natural hydrocolloid-rich flours [*Brachytergia eurycoma* (BE) and *Detarium microcarpum* (DM)] increased. *Sorghum bicolor* flour blended with BE and DM had a lower starch, higher polyphenolics, and stronger antioxidant and digestive enzymes inhibitory properties than the refined *Triticum aestivum* flour. Therefore, *Sorghum bicolor* flour blended with *Brachytegia eurycoma* and *Detarium microcarpum* may be an affordable and healthier alternative to refined *Triticum aestivum* flour, with the potential to promoting food security.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the departmental laboratory of Biochemistry, Kwara State University, Malete, for the facilities used to perform the wet experiments in this study.

REFERENCES

- Batariuc A., Ungureanu-luga M., and Mironeasa S. (2021). Effects of dry heat treatment and milling on sorghum chemical composition, functional and molecular characteristics. *Appl Sci*. 11: 11881. <https://doi.org/10.3390/app112411881>.
- Dongyu Q. (2022). New Scenarios on Global Food Security based on Russia-Ukraine Conflict. Food and Agriculture Organization of the United Nations. <https://www.fao.org/director-general/news/news-article/en/c/1476480/>.
- Ofosu F.K., Elahi F., Daliri E.B.M., Yeon S.J., Ham H.J., Kim J.H., et al. (2020). Flavonoids in decorticated sorghum grains exert antioxidant, antidiabetic and antiobesity activities. *Mol*. 25: 2854.