HOUSEHOLD MICRONUTRIENT IMPREGNATION OF *sorghum bicolor* USING CONVENTIONAL SOAKING

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2026

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Bogor, August 2026

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SUMMARY

PENDAPALA AMADHILA AMADHILA. Household Micronutrient Impregnation of *Sorghum bicolor* using Conventional Soaking. Supervised by DASE HUNAEFI and DIAH CANDRA ARYANI.

Sorghum grain can contain adequate iron and zinc yet still fail to alleviate deficiency because both minerals are concentrated alongside phytic acid, which binds them into poorly absorbed complexes. Consequently, the nutritional value of sorghum (*Sorghum bicolor)* depends more on mineral bioavailability than total mineral content. This is particularly important in arid and semi-arid regions, where sorghum is a staple crop, iron and zinc deficiencies remain widespread, and centralized fortification programs are often inaccessible. This study therefore investigated whether low-cost conventional soaking could simultaneously impregnate whole unhulled sorghum with iron and zinc while reducing phytate, using ultrasound-assisted processing (UAP) as a technological benchmark.

The research was conducted from February to June 2026 at the Food Science and Technology Laboratory, IPB University, using food-grade unhulled sorghum grains. Mineral impregnation was conducted in aqueous solutions of ferrous sulfate heptahydrate ($FeSO_4 \cdot 7H_2O$) and zinc sulfate heptahydrate ($ZnSO_4 \cdot 7H_2O$). Conventional household soaking windows of 6 and 12 hours were evaluated against a 44 kHz (± 6%) ultrasonic water bath with an output of 250 W, applied with and without a 30-minute plain water pre-soak. Iron and zinc concentrations were determined by inductively coupled plasma-optical emission spectrometry (ICP-OES). Phytate was estimated indirectly through a phosphorus-based UV-Vis spectrophotometric assay at 889 nm, and potential bioavailability was expressed as phytate-to-iron and phytate-to-zinc molar ratios (Phy:Fe and Phy:Zn).

All processing treatments significantly altered both mineral density and antinutritional profiles ($p < 0.05$). Raw sorghum contained 28.50 mg/kg iron and 10.06 mg/kg zinc. Mineral soaking for 12 hours (MSS12) raised iron to 58.88 mg/kg, an increase of 106.6%, which was statistically comparable to the non-pre-soaked ultrasound benchmark at 60.45 mg/kg. The difference of 1.57 mg/kg represented 2.7% of the MSS12 value, and the replicate ranges of the two treatments overlapped substantially. Zinc behaved differently, peaking at 39.58 mg/kg after 6 hours (MSS6, a 293.4% increase) before declining to 26.59 mg/kg at 12 hours, a pattern consistent with outward leaching during prolonged soaking. Twelve-hour passive soaking reduced estimated phytate by 51.8%, from 1979.12 mg/kg in the raw control to 953.52 mg/kg, whereas ultrasound-assisted processing left the phytate matrix intact at 1854.52 mg/kg, a reduction of only 6.3%. Consequently, MSS12 achieved the most favorable Phy:Fe molar ratio (1.22), while MSS6 moved the grain into the high zinc bioavailability category with a Phy:Zn ratio of 2.68. A twelve-hour passive soak therefore delivered iron enrichment indistinguishable from the ultrasound benchmark, and a shorter soak retained more zinc, in both cases without specialized equipment.

Keywords: *Bioavailability, impregnation, phytate, sorghum, zinc.*

RINGKASAN

PENDAPALA AMADHILA AMADHILA. Impregnasi Mikronutrien Rumah Tangga pada *Sorghum bicolor* melalui Perendaman Konvensional. Dibimbing oleh DASE HUNAEFI dan DIAH CANDRA ARYANI.

Biji sorgum dapat mengandung besi dan seng dalam jumlah memadai, tetapi tetap gagal mengatasi defisiensi karena kedua mineral tersebut terikat oleh asam fitat menjadi kompleks yang sulit diserap. Oleh karena itu, nilai gizi sorgum (Sorghum bicolor) lebih ditentukan oleh ketersediaan hayati mineral daripada kandungan mineral totalnya. Hal ini penting terutama di wilayah kering dan semi-kering, tempat sorgum menjadi pangan pokok, defisiensi besi dan seng masih tinggi, dan program fortifikasi terpusat sulit dijangkau. Penelitian ini bertujuan mengevaluasi apakah perendaman konvensional berbiaya rendah mampu mengimpregnasi biji sorgum utuh tanpa penyosohan dengan besi dan seng sekaligus menurunkan kadar fitat, menggunakan ultrasound-assisted processing (UAP) sebagai pembanding teknologi.

Penelitian dilaksanakan pada Februari–Juni 2026 di Laboratorium Ilmu dan Teknologi Pangan, IPB University, menggunakan biji sorgum utuh tanpa penyosohan berkualitas pangan. Impregnasi mineral dilakukan menggunakan larutan ferrous sulfate heptahydrate ($FeSO_4 \cdot 7H_2O$) dan zinc sulfate heptahydrate ($ZnSO_4 \cdot 7H_2O$). Perlakuan berupa perendaman konvensional selama 6 dan 12 jam dibandingkan dengan ultrasonic water bath berfrekuensi 44 kHz (±6%) dan daya 250 W, dengan dan tanpa pra-perendaman air selama 30 menit. Kadar besi dan seng dianalisis menggunakan inductively coupled plasma-optical emission spectrometry (ICP-OES). Kadar fitat diestimasi secara tidak langsung menggunakan spektrofotometri UV–Vis berbasis fosfor pada panjang gelombang 889 nm, sedangkan potensi ketersediaan hayati dinyatakan sebagai rasio molar fitat terhadap besi dan seng (Phy:Fe dan Phy:Zn). Seluruh perlakuan berpengaruh nyata terhadap kadar mineral dan profil antinutrisi ($p < 0,05$). Sorgum mentah mengandung 28,50 mg/kg besi dan 10,06 mg/kg seng. Perendaman mineral selama 12 jam (MSS12) meningkatkan kadar besi menjadi 58,88 mg/kg (106,6%) dan tidak berbeda nyata dengan perlakuan ultrasonik tanpa pra-perendaman (60,45 mg/kg). Selisih keduanya hanya 1,57 mg/kg (2,7% dari nilai MSS12) dengan rentang ulangan yang saling tumpang tindih. Sebaliknya, kadar seng mencapai puncaknya setelah perendaman 6 jam (MSS6), yaitu 39,58 mg/kg (293,4%), kemudian menurun menjadi 26,59 mg/kg setelah 12 jam, yang menunjukkan kemungkinan terjadinya pelindian selama perendaman berkepanjangan. Perendaman pasif selama 12 jam menurunkan kadar fitat sebesar 51,8%, dari 1979,12 menjadi 953,52 mg/kg, sedangkan perlakuan ultrasonik hanya menurunkannya sebesar 6,3% menjadi 1854,52 mg/kg. Dengan demikian, MSS12 menghasilkan rasio Phy:Fe terbaik (1,22), sedangkan MSS6 menghasilkan rasio Phy:Zn sebesar 2,68 yang menunjukkan ketersediaan hayati seng tinggi. Hasil ini menunjukkan bahwa perendaman pasif selama 12 jam menghasilkan pengayaan besi yang setara dengan perlakuan ultrasonik, sedangkan perendaman 6 jam mempertahankan kadar seng yang lebih tinggi, keduanya tanpa memerlukan peralatan khusus.

Kata kunci: *Bioavailabilitas, fitat, impregnasi, seng, sorgum.*

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Thesis
Submitted as part of the requirements for obtaining a master's degree in the Food Science Study Program.

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2026

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PREFACE

All praise and glory be to Almighty God, whose grace, strength, wisdom, and unfailing guidance sustained me throughout this journey. His blessings provided me with health, perseverance, and resilience to overcome every challenge and complete this work.

I would like to express my deepest gratitude to my supervisors, Dr. Ing. Dase Hunaefi, S.T.P., M-Foods. and Dr. Diah Chandra Aryani, S.T.P., M.Sc., for their invaluable guidance, patience, encouragement, and unwavering support throughout this research. Their approachable nature, trust, and open-minded mentorship made every discussion productive and every challenge an opportunity to learn, making this research journey both rewarding and enjoyable.

This research was fully funded by the Ministry of Higher Education, Science, and Technology of the Republic of Indonesia, in conjunction with the Ministry of Finance of the Republic of Indonesia, through the Indonesian Aid Scholarship (TIAS). I am sincerely grateful for this life-changing opportunity, which enabled me to pursue postgraduate studies at IPB University and broaden both my academic and personal horizons.

My heartfelt appreciation goes to the International Education Office (IED), IPB University, particularly Dr. Puji Mudiana, Ibu Alfi, Indri, Mikayla Dareen, Sabrina, Rifani, Sylvia, and Mira, for their continuous encouragement, kindness, and unwavering support throughout my stay in Indonesia. Beyond providing outstanding administrative assistance, they consistently encouraged me to participate in university activities, leadership opportunities, and cultural events, making me feel welcomed as part of the IPB community. Their constant motivation, belief in my abilities, and genuine care transformed my academic journey into a truly enriching experience, making it far less stressful and far more memorable than I could have imagined.

I also wish to thank the laboratory technicians and staff of the Department of Food Science and Technology, IPB University, for their invaluable assistance with sample preparation, laboratory analyses, and technical support throughout this study.

My sincere appreciation also goes to Dinda from the IPN Secretariat for her exceptional assistance with administrative matters. Her responsiveness, efficiency, professionalism, and willingness to help ensured that every administrative process was completed smoothly and on time, for which I am truly grateful.

Finally, I would like to thank my fellow master's students (The Fantastic 5), friends, and everyone who, in one way or another, contributed to this journey through their encouragement, friendship, and shared experiences. Their support made my time at IPB University not only academically rewarding but also personally meaningful. To all who have been part of this journey, thank you.

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