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Effect of thermosonication on germination characteristics of finger millet grains (*Eleusine coracana*)

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ABSTRACT

In the present research, the sonication impact of various intensities, temperatures and exposure durations of ultrasound on finger millet grains was examined to identify the most effective conditions for accelerating germination. The study employed the central composite random design for optimization and compared the germination rates and yield of treated seeds with those of untreated seeds grown under normal conditions. During the experiment, the seeds were subjected to ultrasonic energy with input power levels ranging from 40% to 100% of 230 W. Additionally, they were exposed to three different time durations, varying from 8 to 18 minutes and different temperatures *i.e.,* 30-60 °C. The results revealed that the germination of treated finger millet increased by approximately 1-14% compared to the untreated seeds. Furthermore, the ultrasonic treatment significantly reduced the germination period by 7-38% particularly at high temperature. These findings strongly suggest that priming the seeds with ultrasound was highly effective in enhancing water uptake and germination.

Key words: *Ultrasound, Germination, Design expert, Finger millet Malt*

Introduction

Developing nations are primarily focusing on cereal grains, such as rice, wheat, maize, barley, oats, and rye to feed the nation. The progressive depletion of ground water and the climate change causes to shift for millets production. Millets are considerably gaining popularity due to its high nutrient content and higher adaptability to stressed climatic changes (Sruthi and Rao, 2021). Finger millet is primarily grown in Karnataka, Uttarakhand, Maharashtra, Tamilnadu, odisha, Andhra Pradesh and Gujarat (Prabhakar *et al.,* 2017). It has a protein content of about 5-8%, ether extractives of 1-2%, carbohydrates of 65-75%, dietary fibre of 15-20%, and minerals of 2.5-3.5%. Among all minor cereals, finger millet has the highest calcium content, measuring 344 mg/ 100g. Despite containing phytates (0.48%), polyphenols, tannins (0.61%), trypsin inhibitory factors, and dietary fibre, which were once considered "anti-nutrients" due to their metal chelating and enzyme inhibition activities, these components are now recognized as nutraceuticals (Devi *et al.,* 2014).

Ultrasound, a form of energy generated by acoustic waves at frequencies higher than 20 kHz has shown promise in reducing soaking times for various legumes such as chickpeas (Yildirim *et al.,* 2010; Ranjbari *et al.,* 2013), sorghum and (Patero and

Augusto, 2014). This enhanced treatment has been attributed to a more substantial reduction in internal resistance compared to external resistance (Miano *et al.,* 2015). It is believed that the effects of cavitation, micro-channel formation, and the "sponge effect" contribute to improved hydration through inertial flow (Patero and Augusto, 2014). In light of these advancements in ultrasound technology for enhancing the hydration process of seeds and grains, it becomes crucial to study its impact on seed quality, particularly in terms of germination capacity (Miano *et al.,* 2015). Germination plays a vital role in the malting process, which involves steeping, germination, and controlled drying of the germinated seeds at different temperatures and humidities. During germination, hydrolytic enzymes are synthesized, breaking down cell walls, proteins, and endosperm starch compounds, leading to increased brittleness and fragility of the finger millet grains (Farzaneh *et al.,* 2017). As finger millet seeds are crucial for both cultivation and malting, an essential step in beverage production, this study aims to investigate the potential effects of ultrasound technology on the germination of fingermillet grains.

Methods

Raw material

Finger millet (*Eleusine coracana*) of Tirumala variety was purchased from the local market, Bapatla District, Andhra Pradesh, India. Grains with good quality and without any insect infestation were selected and procured. Finger millet gains were cleaned from dust, dirt, immature grains etc and the initial moisture content was measured prior to using it for experimentation.

Ultrasonic pre-treatment

The finger millet grains were pre-treated with ultrasonic treatment. Grains were immersed in distilled water and subjected to ultrasonic waves for different time durations *i.e.,* 8, 13 and 18 minutes. The experiments were conducted using an ultrasonic probe sonicator (Model: DP 120, Make: Dakshin, India) and sonication amplitude of 40, 70 and 100% and temperature of 30, 45 & 60 °C was maintained with the help of mantle. The grain-water ratio was kept at 1:3 by weight basis.

Germination Characteristics

Grains were soaked for 6 hours at room temperature (30 ± 2 °C) after sonication treatment. Germination occurred after 24 hours of steeping. The experiment and controls were conducted in 100 mm petri dishes, with 100 grains per dish and 3 replicates. A layer of moistened filter paper was placed in the petri dishes, and additional water was added as needed. Grains were considered germinated when rootlets were observed at the grain's edge. Germination counts and seedling characterization were performed for 3 days. The total number of germinated seeds to normal seedlings was calculated from zero to the end of the test period using below equation.

$$\text{Germination (\%)} = \frac{\text{Seeds Germinated}}{\text{Total No.of seeds}} \times 100$$

Experimental design

Experiments with time duration, temperature and amplitude were planned with the help of statistical analysis tool namely Design Expert (Stat Ease, MN 55143, USA, Version 12.0.6.0). For this, three independent process parameters namely time duration, temperature and amplitude were selected. Further, response surface model namely central composite design (CCD) was selected. The response parameters were selected as germination (%).

Results and Discussion

Hydration itself is a crucial factor for initiating the germination process. When grains are hydrated during sonication, several factors come into play that influence germination (de Carvalho *et al.,* 2018). Water is essential for activating enzymes and biochemical reactions that break down stored nutrients in the grain, allowing the embryo to develop and grow (Karthika *et al.,* 2018). Hydration during sonication ensures that the grains are thoroughly moist-

Independent process parameters		Factorial and axial values				
		-α	-1	0	+1	+α
Time duration, min	Designed	05	08	13	018	021
Temperature, °C	Experimental	20	30	45	060	70
Amplitude, %	Conditions	20	40	70	100	120

ened, providing the necessary conditions for germination to occur (Miano and Augusto, 2018).

The experiment aimed to determine seed germination percentage by subjecting seeds to ultrasonic treatment. When compared to non-sonicated seeds, those treated at 30 °C for 18 minutes with full amplitude showed an increase in germination from 80% to 95% (Table 1). This improvement can be attributed to mechanical effects caused by ultrasonically induced cavitation, which enhanced water uptake by the cell walls.The most likely mechanism for ultrasonic enhancement of germination is the facilitation of mass transfer and improved water access to the cell wall structure (Singla and Sit, 2021). The collapse of cavitation bubbles near cell walls is expected to disrupt cells and allow water to penetrate through the ultrasonic jet. Analysis of the data revealed that different ultrasonic settings during the germination test significantly affected the extent of germination and resulted in increased germination compared to the control group, indicating the positive impact of ultrasonication on germination of finger millet seeds. However, it should be noted that high cavitation intensity levels may cause damage to the external surface of the finger millet seeds, potentially affecting germination. There is a negative impact of germination when the seeds were exposed to higher temperature especially 60 and 70 ºC. Significant differences in germination percentage were observed with different sonication treatments. The experimental combinations of 13 minutes at 70 °C with 70% amplitude and 18 minutes at 60 °C with 100% amplitude showed the lowest germination rates respectively. At temperatures of 60 and 70 degrees Celsius, the heat generated during sonication can cause significant damage to cellular components and enzymes, leading to decreased germination Fig. 1. The high temperatures may denature enzymes and disrupt cellular structures necessary for the germination process (Nahar *et al.,* 2015). The contrasting effects of sonication amplitude at different temperature ranges suggest an intricate relationship between mechanical forces and temperature. At lower temperatures (30 and 45 °C), higher sonication amplitudes may stimulate beneficial mechanical stimulation, aiding germination processes such as water uptake and enzyme activation. The mechanical forces induced by higher amplitudes may promote the breakdown of seed dormancy and enhance germination. However, at higher temperatures (60 and 70 degrees Celsius), the combination of intense mechanical forces from higher amplitudes and elevated temperatures may exacerbate damage to cellular structures and enzymes, reducing germination and

Table 1. Average experimental values of germination of sonicated finger millet grains

Run	Time (min)	Temperature (°C)	Amplitude (%)	Germination (%)		
				24 h	48 h	72 h
Control	-	-	-	76±0.71	80±0.23	81±0.84
1	08	30	040	81±0.56	92±0.54	93±0.59
2	18	30	040	73±0.25	89±0.84	91±0.23
3	08	30	100	86±0.87	95±0.17	96±0.18
4	18	30	100	80±0.63	91±0.16	92±0.79
5	08	60	040	64±0.58	86±0.48	88±0.56
6	18	60	040	84±0.95	68±0.44	69±0.79
7	08	60	100	70±0.43	80±0.56	82±0.86
8	18	60	100	56±0.87	60±0.24	63±0.48
9	13	45	070	74±0.58	85±0.28	87±0.65
10	13	45	070	73±0.92	82±0.78	88±0.53
11	13	45	070	71±0.15	81±0.59	84±0.89
12	13	45	070	74±0.45	85±0.38	83±0.95
13	13	45	070	75±0.57	80±0.79	85±0.28
14	13	45	070	72±0.58	82±0.56	86±0.49
15	13	45	020	70±0.94	83±0.58	84±0.87
16	13	45	120	76±0.65	87±0.19	88±0.94
17	13	20	070	71±0.47	88±0.87	89±016
18	13	70	070	16±0.23	40±0.95	43±0.94
19	05	45	070	87±0.41	93±0.48	93±0.57
20	21	45	070	64±0.75	72±0.59	74±0.23

these results were agree with Yaldagard *et al. (*2008) in barley grains, ABD-ELSATTAR, (2018) in barley grains, Guimaraes *et al.* (2020) in wheat grains.

The experimental and theoretical results were in close agreement indicated by proximity between R^2 (0.8816) and adjusted R^2 (0.7751) values. The signifi-

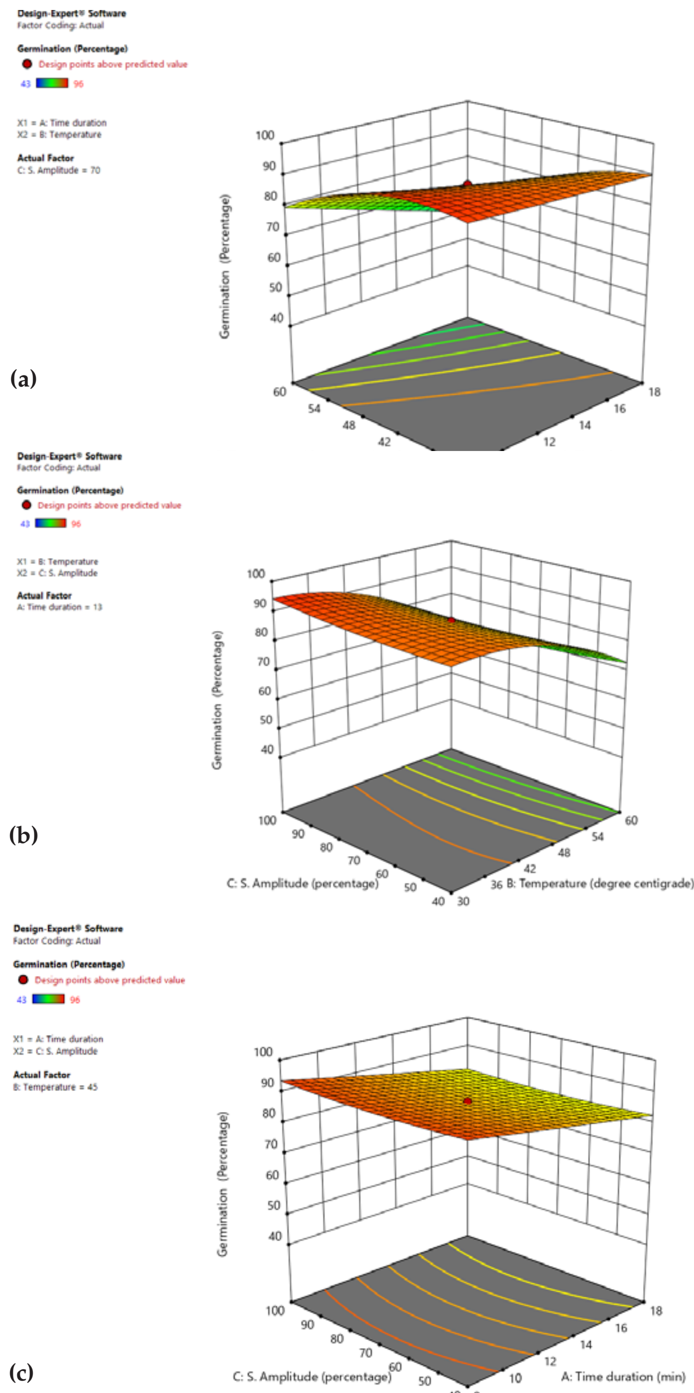

Fig. 1. Effect of process parameters on germination of finger millet during thermosonication
(a) Germination of finger millet grains as a function of time duration and temperature
(b) Germination of finger millet grains as a function of temperature and amplitude
(c) Germination of finger millet grains as a function of time duration and amplitude

cant model terms of germination were A, B and B^2 at $p<0.05$. The germination model regression equation is presented below, along with the impact of process parameters:

Germination = +86.80 -5.56A -10.79B +0.0932C - 4.00AB -0.250AC - 2.00 BC +0.0848A^2 -6.10 B^2 +0.9686C^2

Conclusion

Based on the obtained data, it can be concluded that ultrasonic treatment has a significant effect on finger millet germination, resulting in a shortened germination period depending on the level and exposure time to ultrasonic waves. Furthermore, this research suggests that ultrasonication can be considered a novel and promising method in the agricultural operations industry, as it not only stimulates seed germination but also increases the percentage of germination. This indicates that ultrasonic treatment could potentially enhance productivity for large-scale farm crops.

References

de Carvalho, G.R., Polachini, T.C., Darros-Barbosa, R., Bon, J. and Telis-Romero, J. 2018. Effect of intermittent high-intensity sonication and temperature on barley steeping for malt production. *Journal of Cereal Science*. 82: 138-145.

Devi, P.B., Vijayabharathi, R., Sathyabama, S., Malleshi, N.G. and Priyadarisini, V.B. 2014. Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber: a review. *Journal of Food Science and Technology*. 51(6): 1021-1040.

Farzaneh, V., Ghodsvali, A., Bakhshabadi, H., Zare, Z. and Carvalho, I.S. 2017. The impact of germination time on the some selected parameters through malting process. *International Journal of Biological Macromolecules*. 94: 663-668.

Guimaraes, B., Polachini, T.C., Augusto, P.E. and Telis-Romero, J. 2020. Ultrasound-assisted hydration of wheat grains at different temperatures and power applied: Effect on acoustic field, water absorption and germination. *Chemical Engineering and Processing-Process Intensification*. 155: 108045.

Karthika, K.S., Rashmi, I. and Parvathi, M.S. 2018. Biological functions, uptake, and transport of essential nutrients in relation to plant growth. *Plant Nutrients and Abiotic Stress Tolerance*. 1-49.

Mason, T.J. and Peters, D. 1999. An introduction to the uses of power ultrasound in chemistry. *Practical Sonochemistry; Sonochemistry;* Oxford University Press: New York, NY, USA: 1-48.

Miano, A.C. and Augusto, P.E.D. 2018. The hydration of grains: A critical review from description of phenomena to process improvements. *Comprehensive Reviews in Food Science and Food Safety*. 17(2): 352-370.

Miano, A.C., Forti, V.A., Abud, H.F., Gomes-Junior, F.G., Cicero, S.M. and Augusto, P.E. 2015. Effect of ultrasound technology on barley seed germination and vigour. *Seed Science and Technology*. 43(2): 297-302.

Nahar, K., Hasanuzzaman, M., Ahamed, K.U., Hakeem, K.R., Ozturk, M. and Fujita, M. 2015. Plant responses and tolerance to high temperature stress: role of exogenous phytoprotectants. *Crop Production and Global Environmental Issues*: 385-435.

Patero, T. and Augusto, P.E. 2015. Ultrasound (US) enhances the hydration of sorghum (*Sorghum bicolor*) grains. *Ultrasonics Sonochemistry*. 23: 11-15.

Prabhakar, P.C.G., Boraiah, B., Sujata Bhat, N.C., Kiran, T.V. and Manjunath, H.A. 2017. Improved Production Technologies for Finger Millet. *Project Coordinating Unit ICAR-AICRP on Small Millets GKVK, Bengaluru.* 560(6): 10-12.

Ranjbari, A., Kashaninejad, M., Aalami, M., Khomeiri, M. and Gharekhani, M. 2013. Effect of ultrasonic pretreatment on water absorption characteristics of chickpeas (*Cicer arietinum*). *Latin American Applied Research*. 43(2): 153-159.

Singla, M. and Sit, N. 2021. Application of ultrasound in combination with other technologies in food processing: A review. *Ultrasonics Sonochemistry*. 73: 105506.

Sruthi, N.U. and Rao, P.S. 2021. Effect of processing on storage stability of millet flour: a review. *Trends in Food Science & Technology*. 112: 58-74.

Yaldagard, M., Mortazavi, S.A. and Tabatabaie, F. 2008. Application of ultrasonic waves as a priming technique for accelerating and enhancing the germination of barley seed: Optimization of method by the Taguchi approach. *Journal of the Institute of Brewing*. 114(1): 14-21.

Yildirim, A., Oner, M.D. and Bayram, M.U.S.T.A.F.A. 2010. Modelling of water absorption of ultrasound applied chickpeas (*Cicer arietinum* L.) using Peleg's equation. *Tarim Bilimleri Dergisi.* 16(4): 278-286.