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Determination of Wheat and Corn Seed Volume: A Mathematical and Empirical Approach

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Abstract

This study aims to develop and validate a comprehensive and innovative mathematical and empirical approach to determine the volume of wheat and corn seeds specific to common Iraqi varieties. The objective is to enhance seed farming efficiency and inform related engineering processes by providing accurate volume calculations, which are crucial for designing optimal storage and planting systems and understanding parameters relevant to processes like drying and handling. A sample size of 100 seeds for each crop was used, with measurements taken using a digital caliper to obtain geometric parameters such as length (L), thickness (T) and width (W). SAS software was employed for data analysis, while Origin2018 was utilized to create 3D models of the seeds. The results showed highly significant correlations between the geometric parameters and seed volume, with high R-Square values indicating a strong fit of the mathematical models. Specific equations were developed for wheat and corn volume calculations, demonstrating the potential for these models to be applied in real-world scenarios. The practical application of this research includes enhanced seed metering system, improved planting precision, and optimized resource allocation. This study's findings have significant implications for agricultural engineering, particularly in optimizing seed storage and planting systems, by providing accurate seed volume calculations, this research can contribute to improved crop yield and reduced waste. Further studies could explore applying these methods to other crop types, further enhancing agricultural productivity. Overall, this research offers a novel approach to seed volume determination, supporting advancements in agricultural efficiency and sustainability.

Keywords: Mathematical approach, wheat, corn, geometric parameters, volume.

1. Introduction

The growing demand for wheat and corn in Iraq, driven by population growth and favourable conditions since December 2022, has necessitated improvements in crop management practices. Enhanced rainfall patterns have led to increased yields, requiring better storage systems and planting strategies to manage these surpluses effectively (Morgan, 2023). Accurate characterization of seed physical properties,including volume, is fundamental for both agricultural efficiency and related engineering disciplines. However, despite the criticalroleof geometric properties in agricultural engineering, limited research has been conducted on the specific geometric characteristics of Iraqi wheat and corn varieties.

Seed geometry is a fundamental aspect of agricltural efficiency. Accurate measurements of seed dimensions such as length (L), width(W),and thickness(T) are essential for optimizing crop management systems. These measurerments influence critical processes such as seed metering, planting precision, storage design, and moisture management. Previous studies have demonstrated that geometric properties can predict seed volume (Nelson, 2020; Baslar et al., 2012). Recent studies have further demonstrated that geometric properties like geometric mean diameter and sphericity significantly impact seed volume prediction (Fouda.,et al 2022). (Shi.,et al 2023).

Despite advancements, research on the geometric properties of Iraqi wheat and corn seeds remains scarce. Existing studies often focus on weight-based metrics or lack detailed exploration of geometric parameters (Al-Qassi et al., 2022; Abdel Karim & Mahmoud, 2021).Specifically,while studies like Al-naqeeb., et al (2018) reported weight measurements for local varities like Ibaa 99 and Buhoot22, key geometric details like L,W,T, and derived volume, crucial for engineering design, were often omitted.

This gap limits the ability to develop robust mathematical models tailored to local crop varieties, which are essential for optimizing agricultural practices.Furthermore,while countries like india and Ukraine have extensively studied maize seed geometry (Panwar et al., 2023 ;Palamarchuk & Telekalo, 2018), similar efforts are lacking for Iraqi varieties such as Sarha, Al-maha, Baghdad-3, Alfajer, and khair.

Recent advancements in mathematicical modeling have highlighted the potential of integrating theoretical calculations with empirical data to enhance measurement accuracy. Studies by Alamery & AL-Badri (2023) and Kaliniewicz et al. (2022) have shown that mathematical models can reliably predict seed volume based on geometric parameters like length, width, thickness, and sphericity (Fouda, Abdelsalam, Swilam, & EL Didamony, 2022). These models not only improve measurerment precision but also support practical applications such as designing efficient storage facilities and improving planting systems. Therefore, the primary purpose of this study is to address the specific gap in knowledge regarding the volumetric proprties of key Iraqi wheat and corn varieties by devloping and validating accurate predictive models based on easily measurable geometric dimensions (L,W,T).

This study aims to address these gaps by developing a comprehensive mathematical and empirical approach for determining the volume of wheat and corn seeds. This study bridges the gap by introducing moderately innovative methodologies while revising established approaches to ensure contextual relevance for local agricultural practices.By analyzing key geometric parameters and their impact on seed volume, this research seeks to provide accuraae volume calculations tailored to iraqi crop varieties. The integration of theoretical modeling with experimental validation needed framework offers a novel framework for enhancing agricultural efficiency in local context.

Objectives of the study:

- To quantify the principal geometric parameters (length,width,thickness) for representative samples of common Iraqi wheat and corn varieties.
- To develop statistically robust linear regression models predicting seed volume based on these measured geometric parameters for each crop type.
- To discuss the practical applicability and significance of these validated models for improving agricultural and related engineering (e.g.,storage design, seed metering, handlaing).

1.1 Seed Quality and Sowing Precision

Accurate measurement of grain dimensions helps in determining seed quality (Nelson, 2020), as seeds meeting specific size criteria are more likely to germinate uniformly and establish effectively in the field (Ali, Abdulateef, & Yahya, 2022). This study builds upon prior research that emphasizes the importance of geometric properties in agricultural efficiency. For instance, Nelson (2020) highlighted the use of volume coefficients to estimate see density from dimensional data,which underscores the practical relevance of precise geometric measurments.

However, despite its importance ,there is a notable gap in research on the geometric properties of Iraqi wheat and corn varieties. Studies such as those by Al-Qassi et al. (2022) and Abdel Karim & Mahmoud (2021) primarily focus on weight-based metrics or lack detailed exploration of geometric parameters. Similarly, Al-naqeeb et al. (2018) reported on weight measurements but omitted key geometric details like length, width, and thickness. As mentioned previously, this lack of specific geometric data hinders the optimization of equipment and processes tailored to these varieties. These gaps highlight the need for a more comprehensive approach to understanding seed geometry, particularly for Iraqi varieties Table.1. The same issue exists with research for corn in Iraq; there is a lack of information related to the Iraqi varieties of corn such as Sarha, AL-Maha, Baghdad3, Alfajer, and Khair.

Equations using the laws of mixtures can predict kernel and bulk volume changes during moisture adsorption or desorption. Volume coefficients, derived from the ratio of measured volume to the product of orthogonal dimensions, enable estimation of seed volume and density from dimensional data (Nelson, 2020). The volume coefficient can be used to estimate

seed density from seed weight and dimensions (Baslar.,et al 2012). At the same time there is a lack of information related to corn in Iraq,while other contrries are interested in studying corn geometric properties (Panwar.,et al 2023)(Palamarchuk & Telekalo, 2018)(Chen.,et al 2020) and

Table 1: illustrates that many studies were not interested in studying the geometric properties.

No	Product Name	Farming Country	Length (mm)	Width (mm)	Thickness (mm)	Size (mm^3)	Geometric Mean Diameter (mm)	Sphericity (%)	Surface area (mm^2)	References
1	Ibaa99	Iraq	#	#	#	#	#	#	#	(Al-naqeeb, Hameed, Hamza, Mahdi, & Karim, 2018)
2	Buhooth22	Iraq	#	#	#	#	#	#	#	
3	Abu-Ghraib3	Iraq	#	#	#	#	#	#	#	
4	Abu Ghraib 3	Iraq	#	#	#	#	#	#	#	(Al-Qassi, Anees, hussein, El- Hosary, & M., 2022)
5	Latifia	Iraq	#	#	#	#	#	#	#	
6	Aba 99	Iraq	#	#	#	#	#	#	#	
7	Tamuz 3	Iraq	#	#	#	#	#	#	#	
8	Rashid	Iraq	#	#	#	#	#	#	#	
9	Aba 95	Iraq	#	#	#	#	#	#	#	
10	Research 22	Iraq	#	#	#	#	#	#	#	
11	Jihan	Iraq	#	#	#	#	#	#	#	
12	Adana	Iraq	#	#	#	#	#	#	#	
13	Abu–Graib3	Iraq	#	#	#	#	#	#	#	(Al-Baldawi, Al-Hedarey, & Hamza, 2017)
14	IPA99	Iraq	#	#	#	#	#	#	#	
15	Al-Fateh	Iraq	#	#	#	#	#	#	#	(Baktash & Hassan, 2015)
16	Al-fatah	Iraq	#	#	#	#	#	#	#	
17	IPA99	Iraq	#	#	#	#	#	#	#	
18	Abu-Ghraib3	Iraq	#	#	#	#	#	#	#	

Moreover, advancements in mathematical modelling have provided critical insights into seed dimensions for estimating volume coefficients with high accuracy (Alamery & Al-Badri, 2023;Kaliniewicz, Choszcz, & Lipinski, 2022). These models provide critical insights into seed dimensions to estimate volume coefficients with high accuracy. Building on this foundation, this study integrates both mathematical and empirical approaches to address gaps in existing literature and provide practical tools for farmers and engineers.

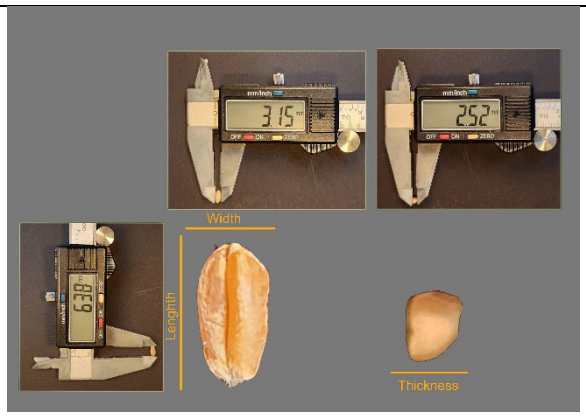
Furthermore, research by Baslar et al. (2012) revealed that volume cofficients derived from orthogonal dimensions could predict kernel and bulk volume change during moisture

adsorption or desorption. This finding is particularly relevant for optimizing storage conditions and ensuring seed viability over time.

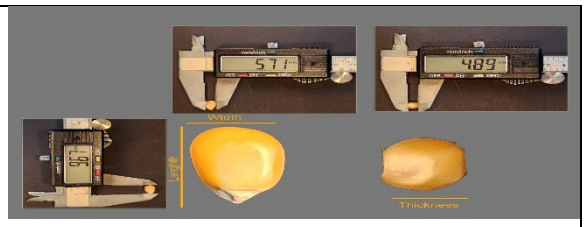
Need for Comprehensive models in Iraqi Agriculture: While other countries have extensively studied the geometric properties of crops like maize (Panwar, et al.,2023; Palamarchuk & Telekalo, 2018), similar studies are scarce in Iraq.The lack of detailed data on wheat and corn varieties grown in Iraq limits the ability to optimize storage systems and planting strategies effectively.This study aims to fill this gap by developing roubust mathematical models tailored to Iraqi wheat and corn varieties,incorporating key geometric parameter such as length(L), width (W), and thickness (T).

2. Materials and Methods

A digital calliper was used to measure the geometric parameters. The study employs a linear regression model to predict seed volume based on length, width, and thickness (Alamery & Al-Badri, 2023) (Haghshenas, Emam, & Jafarizadeh, 2022) of 100 seeds for each crop. This sample size was selected based on statistical power analysis requirements for regression models, ensuring a confidence level of 95% and margin of error ≤5% (Honfo et al., 2019). This choice is justified by the high R-Square values obtained, indicating a strong fit between the model and the empirical data. Moreover, by leveraging advanced statistical tools SAS software (version9.4) for regression analysis and Origin2018 for 3D modeling, this research provides a validated framework for understanding seed geometry's role in agricultural productivity within the Iraqi context. The selection of SAS over alternatives like R or Python was driven by its proven robustness in handling large agricultural datasets and compliance with regulatory standards (Bhardwaj & Kaushik , 2024). This approach not only enhances measurement accuracy but also supports real-world applications such as improved seed metering systems and resource allocation strategies.



The measurements of wheat grain



The measurements of corn grain

Figure 1: Shown the methods for measuring geometric properties.

3. Results and Discussions

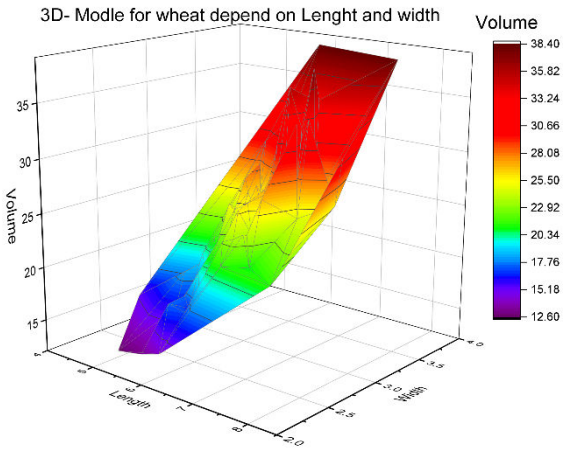
The results in Table -2- showed that the overall model had a highly significant impact, $F_{(3,99)}$=3540.03, $p < 0.0001$; R^2= 0.9910, Adj R^2= 0.9908, and RMSE=0.5423. All W, T, and L were highly significant. This study indicates a robust correlation between geometric dimensions and the volume of wheat seeds, with high R^2 value of 0.9910. This strong relationship suggests that farmers can effectively use these geometric measurements to predict seed volume, which is crucial for optimizing strategies, leading to potentially improved crop yields and more efficient resource allocation. This is a valuable tool for enhancing seed quality assessment and ensuring uniform germination rates. Furthermore, understanding the volume of wheat seeds can aid in designing more efficient storage solutions (Alsbu, Yarlagadda, & Karim, 2023). As Iraq faces increasing demand for wheat due to population growth, accurate volume prediction will help in developing storage bins that minimize spoilage and maintain seed viability.

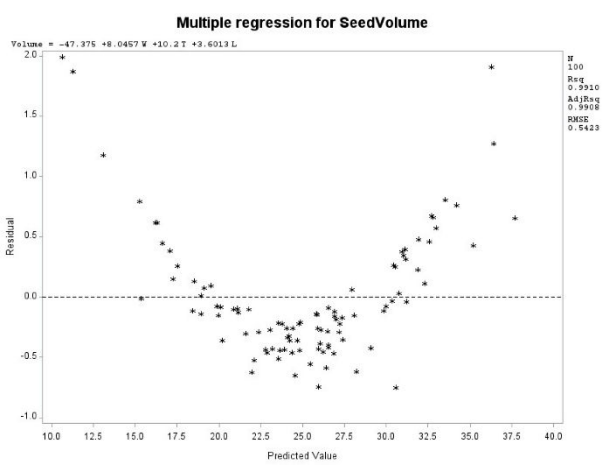
Table 2 Overall results of the wheat volume, The Reg Procedure, MODLEI, Dependent

Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Model	3	3123.35596	1041.11856	3540.03	<.0001
Error	96	28.23350	0.29410		
Corrected Total	99	3151.58946			

Root MSE	0.54231	R-Square	0.9910
Dependent Mean	25.16899	Adj R-Sq	0.9908
Coeff Var	2.15467		

Variable	DF	Parameter Estimate	Standard Erro	T Value	Pr > t	Standardized Estimate	Tolerance	95% Condidence Limits	
Intercept	1	-47.37549	0.75637	-62.64	<.0001	0	.	-48.87687	-45.87412
W	1	8.04568	0.21504	37.41	<.0001	0.45158	0.64057	7.61883	8.47254
T	1	10.20022	0.23294	43.79	<.0001	0.50725	0.69542	9.73783	10.66260
L	1	3.60126	0.10513	34.26	<.0001	0.34913	0.89834	3.39258	3.80994





Volume = -47.375+8.0457W+10.2T+3.6013L.

Figure 2: 3D model was developed based on the data for wheat measurement

The results in Table -3- showed that the overall model had highly significant impact, $F_{(3,99)}$=6016.62, $p < 0.0001$; R^2= 0.9947, Adj R^2= 0.9945, and RMSE=1.70847. All W, T, and L were highly significant. This indicates that the geometric parameters of corn seeds can be reliably used to estimate their volume, which is essential for ensuring optimal planting density and maximizing yield. This not only assists in seed quality control but also contributes to effective crop management practices. The ability to accurately measure corn seed volume has significant implications for post-harvest management. With precise volume data, agricultural engineers can design storage facilities that accommodate varying volumes of corn, thereby reducing waste and ensuring better preservation of grain quality (Alsbu, Yarlagadda, & Karim, 2023).

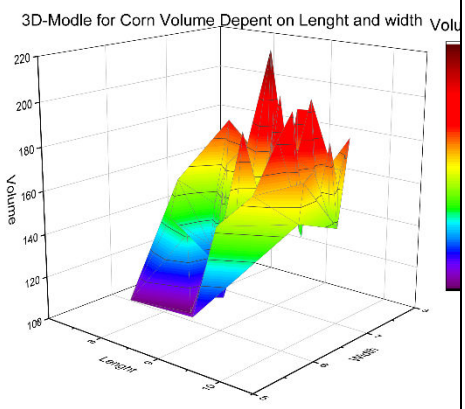
Table 3 Overall results of the corn volume, The Reg Procedure, MODLEI, Dependent

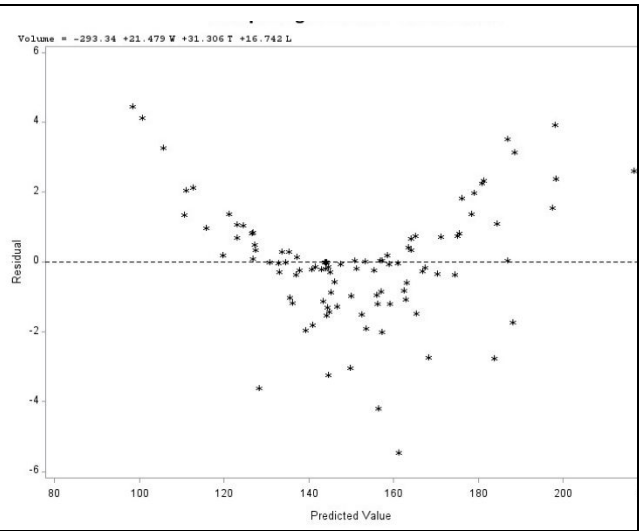
Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Model	3	52687	17562	6016.62	<.0001
Error	96	280.21227	2.91888		
Corrected Total	99	52967			

Root MSE	1.70847	R-Square	0.9947
Dependent Mean	151.0793	Adj R-Sq	0.9945
Coeff Var	1.13084		

Variable	DF	Parameter Estimate	Standard Erro	T Value	Pr > t	Standardized Estimate	Tolerance	95% Condidence Limits	
Intercept	1	-293.33586	3.96474	-73.99	<.0001	0	.	-301.205	-285.4659

								8	
W	1	21.47886	0.39398	54.52	<.0001	0.40705	0.98853	20.69682	22.26090
T	1	31.30625	0.29000	107.95	<.0001	0.80184	0.99887	30.73061	31.88189
L	1	16.74187	0.32176	52.03	<.0001	0.38846	0.98864	16..10317	17.38057





Volume =-293.34+21.479W+31.306T+16.742L.

Figure 3: 3D model was developed based on the data for corn measurement

In summary, the geometric analysis of both wheat and corn seeds offers critical insights for improving agricultural efficiency in Iraq. The developed mathematical models serve as practical tools for farmers and agricultural engineers, facilitating better decision-making regarding planting and storage practices. Future research should continue to explore these methodologies across different crops to further enhance agricultural productivity and sustainability.

Table 4 Overall results of the wheat and corn volume, The Reg Procedure, MODLEI, Dependent

Source	DF	Sum of Squares	Mean Square	F Value	Pr>F
Model	3	839482	279827	5892.34	<.0001
Error	196		47.4848997		
Corrected Total	199				

Root MSE	6.89130	R-Square	0.9890
Dependent Mean	88.12417	Adj R-Sq	0.9890
Coeff Var	7.81999		

Variable	DF	Parameter Estimate	Standard Erro	T Valu e	Pr > t	Standardized Estimate	Toler ance	95% Condidence Limits	
Intercept	1	-130.63363	3.85348	-33.90	<.0001	0	.	-301.2058	-123.0340
W	1	12.04129	0.86609	13.90	<.0001	0.34969	0.08844	10.33324	13.74934
T	1	25.86947	1.01869	25.39	<.0001	0.48005	0.15657	23.86048	27.87846
L	1	8.60164	0.87840	9.79	<.0001	0.19594	0.13974	6.86931	10.33397

The findings from this study have far-reaching implications for agricultural engineering and related fields (Su, et al., 2021). Accurate seed volume calculations can aid in designing efficient storage facilities and planting systems, ultimately leading to better crop yields and reduced waste (Alsbu et al,. 2023).

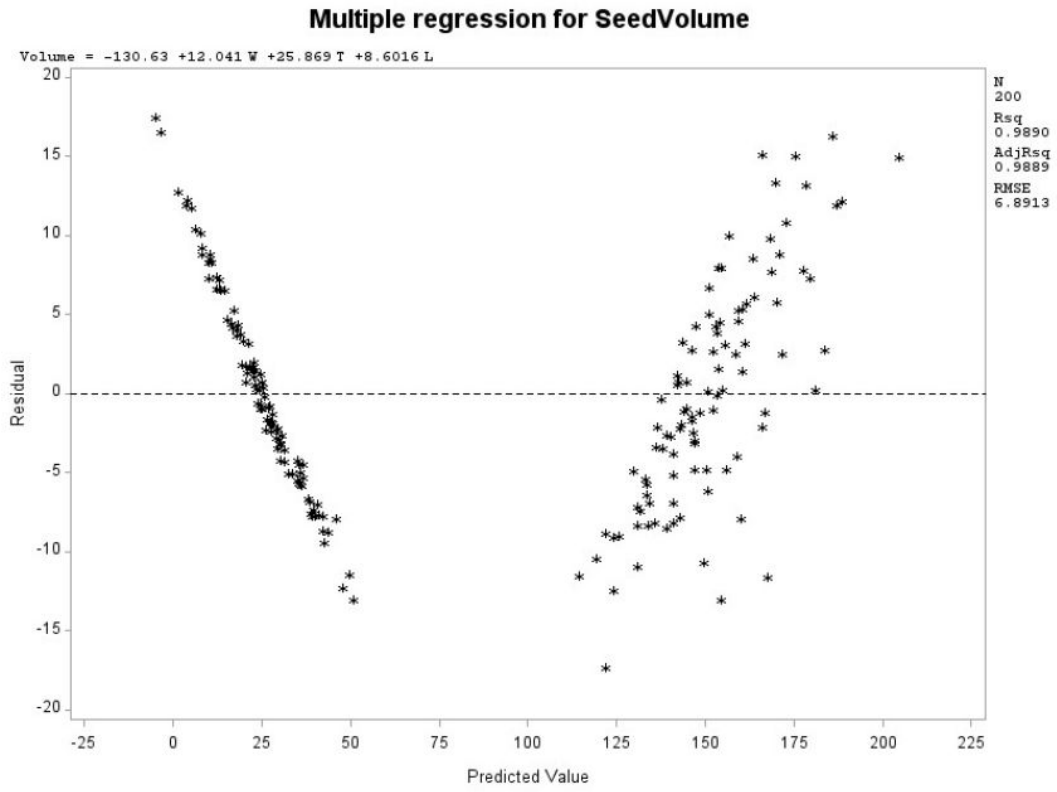


Figure 4: 3D model was developed based on the data for wheat and corn

4. Discussion

The findings of this study demonstrate that using geometric measurements (length, width, and thickness) is an effective method for determining the volume of wheat and corn seeds for the Iraqi varieties studied. This approach provides a simple, non-destructive alternative to more complex methods such as imaging technologies.

The results showed strong statistical support for this methodology, with an R^2 value exceeding 0.989 and highly significant F-statistics ($p < 0.0001$), indicating high accuracy and reliability in predicting seed volume based on geometric dimensions. The low Root Mean Square Error (RMSE) values (0.54 for wheat,1.71 for corn) further suggest good predictive capability relative to the scale of the volumes measured

One of the key contributions of this research is its ability to address practical challenges in agricultural science and food biotechnology (e.g., seed grading, milling efficiency). Accurate seed volume determination is essential for processes such as seed grading, storage optimization, and quality control. Accurate volume data enables more precise calculation of bulk density, which is critical for designing storage silos and predicting load capacities, potentially leading to more efficient use of storage infrastructure (Quantify impact where possible, e.g., potential storage space saving estimates). Furthermore, understanding seed volume can aid in predicting kernel density- a critical parameter for milling efficiency yield.

While robust, this methodology assumes that seeds approximate regular geometric shapes (e,g ellipsoids), which may not fully account for irregularities in morphology or variations due to damage or genetic differences. This limitation could introduce minor errors in volume estimation for highly irregularly shaped seeds.

The practical implications of this research are significant for Iraqi agriculture. Integrating geometric volume data into automated systems could improve efficiency in storage processes while supporting sustainability efforts by reducing waste during processing. Additionally, this methodology can be applied to assess quality traits such as s shrinkage during drying or swelling during germination- critical factors in food biotechnology. Finally, this study highlights the importance of accessible methodologies for addressing complex challenges in agricultural science and food biotechnology. By providing a framework for accurate seed volume determination using simple tools like digital callipers, this research supports advancements in both fields while focusing on further exploration into related applications such as germination studies or optimization of storage systems.

Future research should focus on integrating emerging technologies such as AI-driven modelling using image analysis or precision agriculture systems to enhance applicability across diverse crop types and environmental conditions.

5. Conclusion

This study successfully developed and validated a mathematical and empirical approach for determining the volume of wheat and corn seeds, providing accurate calculations based on

geometric parameters. The results showed that a strong relationship between these parameters and seed volume with highly significant statistical results (F-values and R-Squared values exceeding 0.99) indicating robust model fit and high predictive accuracy for the varieties tested. Specific equations were developed for each crop type, demonstrating that potential for practical application in agricltueral engineering and related process design.

Furthermore, monitoring grain dimensions can serve as an indicator of their developmental health, enabling farmers to identify potential nutrient deficiencies or stress conditions early on. By integrating these measurement techniques into agricultural practices farmers can make informed decisions regarding resources allocated and management strategies.

In conclusion, this study successfully developed mathematical models for determining the volume of wheat and corn seeds, offering a reliable method for optimizing agricltural practices. Future research should focus on expanding these midels to other local crops, investigating the influence of moisture cotent, and integrating emerging technologies like machine vision and AI to further improve agricultural productivity and sustainability and bridge the gapwith advanced process angineering applications.

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