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IMPACT OF SOAKING TIME ON THE WATER ABSORPTION BEHAVIOUR OF SOYBEAN GRAINS AT DIFFERENT (40°C, 50°C AND 60°C) TEMPERATURE

S.D. Bhosale[1]*, K.J. Kamble[1] and V.P. Kad[2]

[1]Department of Agricultural Process Engg., M.P.K.V., Rahuri, Maharashtra, India.

[2]Department of Food Science Technology, M.P.K.V., Rahuri, Maharashtra, India.

*Corresponding author E-mail : agroneershubs24@gmail.com

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ABSTRACT

Soybeans belong to the Leguminosae family as well as the Papilionaceae subfamily. Soymilk have been regarded as a valuable source of high-quality protein. It is also used as a lactose-intolerant milk substitute, as well as a low-cost source of high-quality protein and calories, primarily in developing countries. Soymilk contained a significant amount of essential amino acids, except for methionine. It is high in B vitamins like niacin, pyridoxine, and folacin. Soymilk is a good source of polyunsaturated fatty acids and low-cost protein. Soybean is the prominent agricultural crop for high-quality concentrated proteins and vegetable oil. It has an ability to relieve and protect menopausal symptoms and breast cancer, heart disease, respectively. Antinutrients like trypsin inhibitor, phytate could be reduced by soaking, fermenting, and heating it. Some research emphasises on traditionally cooked and lightly processed soy meals for providing modest health benefits, by lowering the negative health effects.

Traditionally, soymilk is made by soaking soybeans in water overnight, then grinding the beans with water during the grinding process. But if we soak the soybean grains many factors influence the quality of soy milk, such as soybean seed soaking conditions, storage, and enzymes found in soybeans. As a result, the current study was carried out to investigate the effect of soaking time on the water absorption behaviour of soybean, which would affect the yield and quality of soymilk. From this study, it has been clear that for the preparation of soymilk, the soybean grains can be soaked at 40°C for 9 hours, 50°C for 8 hours and 60°C at 7 hours for hydration of whole soybean.

Key words : Soymilk, High- quality protein, Soaking Hydration.

Introduction

Soybeans belong to the Leguminosae family as well as the Papilionaceae subfamily. In 1948, Ricker and Morse proposed the correct nomenclature for the cultivated soybean, *G. max* (L.) Merrill (Gazzoni, 1994). Among agricultural crops, soybean is the most important source of high-quality concentrated proteins and vegetable oil. For centuries, Asian and other parts of the world have used soybean seeds to make a variety of fresh, fermented, and dried dishes (Probst and Judd, 1973). Soy-based nutritious food products such as tofu, soy milk, soy sauce, miso, etc. and oil are well known for consumption and soy meal as a nutritious animal feed (Pratap *et al.*, 2012).

In light of soy's health benefits, it has been discovered that soy foods and isoflavones may relieve menopausal symptoms and protect against breast cancer and heart disease. Because studies have found both increases and decreases, it appears that soy supplementation affects thyroid function unevenly. Some antinutrients in soy could be reduced by soaking, fermenting, and heating it. According to the author's findings, small amounts of traditionally cooked and lightly processed soy meals may provide modest health benefits while lowering the risk of negative health effects (Cristopher and Aziz, 2014).

The de oiled cake (DOC) is exported to other countries but it is utilized to prepare the other products

like nuggets and other products such as soy nuts and sprouts etc. The tofu is prepared by lesser extent. Soy milk is the most popular drink in the tropical countries like India.

Soymilk is an aqueous extract of whole soybeans that, in appearance, composition, and energy source, is like dairy milk. Properly prepared soymilk provided numerous nutraceutical and health benefits. Soymilk has long been regarded as a valuable source of high-quality protein. Soymilk is also used as a lactose-intolerant milk substitute, as well as a 5 low-cost source of high-quality protein and calories, primarily in developing countries. Soymilk contained a significant amount of essential and branched chain amino acids, with the exception of methionine. It is high in B vitamins, such as niacin, pyridoxine, and folacin. Soymilk is high in polyunsaturated fatty acids and low in protein.

Traditionally, soymilk is made by soaking soybeans in water overnight, then grinding the beans with water added during the grinding process. The soymilk slurry can also be made with full fat flakes, grits, or flour. For 1-30 minutes, the resulting slurry is boiled and stirred (depending on the temperature). This heating step increases the nutritional value of the milk and improves the flavour by inactivating trypsin inhibitors (by inactivating lipoxygenase and volatizing some of the off-flavour compounds that result during grinding). Heating milk also extends its shelf life by reducing its microbial load. The heated slurry is then filtered through a cloth or nylon bag to separate the soymilk from the undispersible fibre residue (okara). (2003) (Snyder and Wilson). Many factors influence the quality of soy milk, including soybean seed soaking conditions, storage, and enzymes found in soybeans (Penaranda and Reitmeier, 2001).

According to the researchers, soaking should be done overnight. As a result, the current study was carried out to investigate the effect of soaking time on the water absorption behaviour of soybean, which would affect the yield and quality of soymilk.

Materials and Methods

Materials

The JS-9305 soybean variety was obtained from APMC Market in Rahuri (Maharashtra). The soybeans were manually sorted, with broken seeds and stones removed. For the soaking experiment, cleaned soybean was used.

Soybean soaking process

Clean soybean grains (50 gm) were soaked in water in a 1:3 (w/v) ratio at different temperatures (40°C, 50°C and 60°C) until saturation.

Determination of soaking characteristics

Weight of soaked sample : Every one hour, the weight of the soaked sample was measured. Before weighing, the samples were drained,

Water absorption (%) : The hydration process was examined in terms of water absorption percentage (Munu *et al*., 2016).

Percentage water absorption was determined as,

$$\%W = \frac{Wf - W0}{W0} \times 100 \quad (1)$$

Where, % W = Percentage water absorption

Wf = Soybean weight after soaking, gm

Moisture content (%, d.b.) : The moisture content of the soybean will be determined using the hot air oven method as well. The moisture content of grains is determined by heating the grain in a hot air oven at 100-110°C for 24 hours. The following equation was used to determine it. (http://ecoursesonline.iasri.res.in/mod/page/view.php?id=124179)

Moisture Content (db), % =

$$\frac{\text{Initial Weight of sample}(W_1) - \text{Final Weight}(W_2)}{\text{Final Weight of sample}(W_1)} \times 100 \quad (2)$$

Results and Discussion

The soaking characteristics of soybean grains at different (40°C, 50°C and 60°C) water temperature shows in Table 1.

Effect of Soaking time on soybean grains at 40°C

At 40°C soaking water temperature, the moisture content of soybean grain increased from 15.51 % to 150.00% (Fig. 1). The water absorption by the soybean grain is a diffusion process and is controlled by concentration gradient. According to Fig. 1, the initial water uptake is high due to the high-water concentration gradient between the soaking medium and the dry soybean grains. The water absorption rate gradually decreased as the soaking process progressed due to a decrease in the water concentration gradient. According to Sayar and colleagues (2001) and Abu Ghannam and Mckenna (1997), this is due to water filling into the intercellular spaces. During the first hour of soaking, the rate of water absorption was rapid. The moisture content (%, d.b) increased from the initial 15.51 % to 82.21%. From the second hour to 9th hour of soaking water absorption was gradual and increased the moisture content to a maximum of 150.00%

Table 1 : Effect of Soaking time on soybean grains at 40°C.

Hours (Hrs)	Initial weight of grains, gm	Final weight of grains, gm	Water Absorption, %	Moisture content, % wb	Moisture content, % db
0	50	50	-	13.43	15.51
1	50	85.23	41.34	45.12	82.21
2	50	95.66	47.73	51.55	106.39
3	50	101.21	50.6	51.91	107.94
4	50	104.77	52.28	53.03	112.90
5	50	106.64	53.11	57.86	137.30
6	50	108.3	53.83	58.54	138.89
7	50	109.5	54.34	59.14	144.73
8	50	110.96	54.94	59.8	148.75
9	50	111.42	55.12	60	150.00
10	50	111.42	55.12	60	150.00
11	50	111.42	55.12	60	150.00

(d.b.). At the 9th hour the, moisture content remains same as 150.00% (d.b.). The similar trend was reported by Munu *et al.* (2016). As the water absorption percentage remains same after 9th hour, the moisture ratios at the same hours remains constant. It shows in Fig. 1.

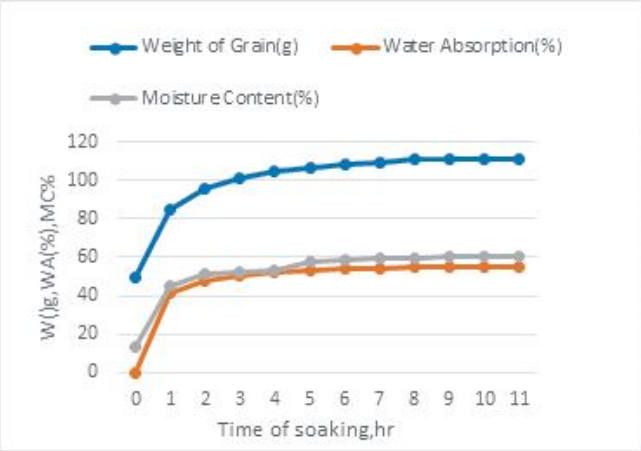

Fig. 1 : Effect of soaking time on weight of grain (gm), water absorption and Moisture content of soybean grain at 40°C.

- **F-statistic**: **14.64**
- **Significance F (p-value)**: **0.00334**
  - This indicates that the regression model is statistically significant overall ($p < 0.05$), meaning the independent variable contributes meaningfully to explaining the variance in the dependent variable.

Term	Coefficient	Std. Error	t-Stat	p-value	95% CI
Intercept	-10.23	4.17	-2.45	**0.034**	(-19.52, -0.94)
X Variable 1	**0.156**	0.041	3.83	**0.0033**	**(0.065, 0.248)**

- The **coefficient for X Variable 1 is 0.156**:
  - For every 1 unit increase in X, the dependent variable increases by approximately 0.156 units.
- The **p-value for X Variable 1 is 0.0033**, which is **highly significant** ($p < 0.01$).

❖ **Conclusion / Remarks**

- The model shows a **strong and statistically significant relationship** between the independent variable (X Variable 1) and the dependent variable.
- The **positive coefficient** suggests that as X increases, the dependent variable also increases.
- The **intercept is negative**, but its interpretation depends on whether a value of X = 0 is meaningful in your context.
- The R^2 value (0.594) indicates a **moderate fit**: over half of the variability in the dependent variable is explained by X.

ANOVA (Model Significance)

- **F-statistic**: **7.54**
- **Significance F (p-value)**: **0.0206**
  - The model is **statistically significant** at the 5% level ($p < 0.05$), indicating the independent variable has a meaningful effect on the dependent variable.

Term Coefficient Std. Error t-Stat p-value 95% Confidence Interval
Intercept -1.746 2.765 -0.631 0.542 (-7.91, 4.42)
X Variable 1 0.152 0.055 2.75 **0.021 (0.029, 0.275)**

- **Variable 1 coefficient**: **0.152**

Table 2 : Effect on weight of grain after every hour.

Regression Statistics								
Multiple R	0.7708							
R Square	0.5941							
Adjusted R Square	0.5535							
Standard Error	2.4093							
Observations	12							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	84.9549	84.9549	14.6360	0.0033			
Residual	10	58.0451	5.8045					
Total	11	143						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-10.2270	4.1693	-2.4529	0.0341	-19.5167	-0.9372	-19.5167	-0.9372
X Variable 1	0.1564	0.0409	3.8257	0.0033	0.0653	0.2475	0.0653	0.2475

- This means that **for every 1 unit increase in X, water absorption increases by approximately 0.152 units**.

- **p-value for X Variable 1**: **0.0206**, which is statistically significant ($p < 0.05$).
- **Intercept**: Not statistically significant ($p = 0.542$), indicating that when $X = 0$, the predicted water absorption value is not reliably different from zero — may not have a practical interpretation unless $X = 0$ has a meaningful context.

➢ **Conclusions / Remarks**

- The regression model shows a **moderate** but **statistically significant** relationship between X and water absorption at 40°C.
- The independent variable (X) has a **positive and significant effect** on water absorption.
- About **43%** of the variation in the dependent variable is explained by the model, suggesting other factors may also influence water absorption and could be included in future models.
- The **intercept is not significant**, but this does not affect the interpretation of the slope.

ANOVA (Model Significance)

- **F-statistic**: **26.40**
- **Significance F**: **0.0004**

- The regression model is **highly statistically significant** ($p < 0.001$), meaning the independent variable strongly influences the dependent variable.

Term	Coefficient	Std. Error	t-Stat	p-value	95% CI
Intercept	-3.7623	1.8914	-1.989	0.0747	(-7.977, 0.452)
X Variable 1	**0.0769**	0.0150	5.138	**0.0004**	**(0.0436, 0.1103)**

X Variable 1 coefficient: **0.0769**

- For every 1-unit increase in X, the dependent variable increases by approximately 0.077 units.

p-value for X Variable 1: **0.0004**

- **Highly significant** ($p < 0.001$), confirming a **strong relationship** between X and the dependent variable.

Intercept: Not statistically significant ($p = 0.0747$), which means its value is less reliable or interpretable unless $X = 0$ is meaningful in context.

Conclusion / Remarks

- The model demonstrates a **strong and statistically significant relationship** between X and the dependent variable.
- With an **R^2 of 72.5%**, it explains a large portion of the variance, indicating that the predictor variable is a **key driver** of the response.
- The **coefficient of X is positive and**

Table 3 : Summar output at 40°C water absorption.

Regression Statistics								
Multiple R	0.6555							
R Square	0.4297							
Adjusted R Square	0.3727							
Standard Error	2.8556							
Observations	12							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	61.4527	61.4527	7.5358	0.0206			
Residual	10	81.5473	8.1547					
Total	11	143						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-1.7461	2.7653	-0.6314	0.5419	-7.9076	4.4155	-7.9076	4.4155
X Variable 1	0.1516	0.0552	2.7451	0.0206	0.0286	0.2747	0.0286	0.2747

significant, suggesting a consistent positive effect.

- The **intercept is not statistically significant**, but this has little impact unless the context requires interpretation at X = 0.
- **Effect of Soaking time on soybean grains at 50°C**

The weight of soybean grain, water absorption and moisture content after every hour of soaking of the soybean grains when the soybean grains soaked at 50°C is shown in Table 5.

ANOVA (Analysis of Variance)

- **F-statistic = 13.9388**, with a **Significance F = 0.0047**
  - o This indicates the overall model is **statistically significant** at the 0.01 level.
  - o There is **strong evidence** that the independent variable helps explain the dependent variable.

Regression Coefficients

Term	Coefficient	Std. Error	t-Stat	p-value	95% CI
Intercept	-9.1272	3.8411	-2.376	0.0415	(-17.8164, -0.4380)
X Variable 1	0.1414	0.0379	3.734	0.0047	(0.0557, 0.2271)

Intercept (-9.1272):

- Statistically significant (p = 0.0415).
- When X = 0, the predicted grain weight is -9.13 units, which may not be meaningful in practice unless zero input has context.

X Variable 1 (0.1414)

- Highly significant predictor (p = 0.0047).
- For every **one-unit increase in X**, the **grain weight increases by approximately 0.1414 units**.
- The 95% confidence interval (0.0557 to 0.2271) does **not** include zero, confirming its statistical significance.

Conclusion / Remark

The regression analysis shows a statistically significant positive relationship between X Variable 1 and the weight of grain at 50°C. The model explains approximately 61% of the variation in grain weight, and the predictor variable is a strong and significant contributor. These results suggest that increases in X Variable 1 are associated with meaningful increases in grain weight under the given conditions.

ANOVA (Analysis of Variance) for moisture content after every hour

- **F-statistic = 25.4202**
- **Significance F = 0.0007**
  - o Indicates the model is **highly statistically significant** (p < 0.01).
  - o There's **strong evidence** that the independent variable significantly affects moisture content.

Table 4 : Effect on MC db at 40 °C.

Regression Statistics								
Multiple R	0.8516							
R Square	0.7252							
Adjusted R Square	0.6978							
Standard Error	1.9822							
Observations	12							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	103.7094	103.7094	26.3955	0.0004			
Residual	10	39.2906	3.9291					
Total	11	143						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-3.7623	1.8914	-1.9891	0.0747	-7.9767	0.4522	-7.9767	0.4522
X Variable 1	0.0769	0.0150	5.1377	0.0004	0.0436	0.1103	0.0436	0.1103

Regression Coefficients

Term	Coefficient	Std. Error	t-Stat	p-value	95% CI
Intercept	-3.2927	1.7308	-1.9024	0.0895	(-7.2082, 0.6227)
X Variable 1	0.0699	0.0139	5.0418	0.0007	(0.0385, 0.1012)

➢ Intercept (-3.2927)

- **Not statistically significant** (p = 0.0895), as the confidence interval includes zero.
- This means the value of MC when X = 0 may not be meaningfully estimated by the model.

X Variable 1 (0.0699)

- **Highly statistically significant** (p = 0.0007).
- For every **one-unit increase in X**, the **moisture content increases by approximately 0.0699 units**.
- The confidence interval (0.0385 to 0.1012) confirms the positive and significant effect.

Conclusion / Remark

The regression analysis shows a **strong and statistically significant positive relationship** between X Variable 1 and the moisture content (MC db) at 50°C. The model accounts for approximately **74%** of the variation in moisture content, suggesting a robust predictive capability. Although the intercept is not statistically significant, the predictor variable (X Variable 1) has a **clear and meaningful effect** on moisture content.

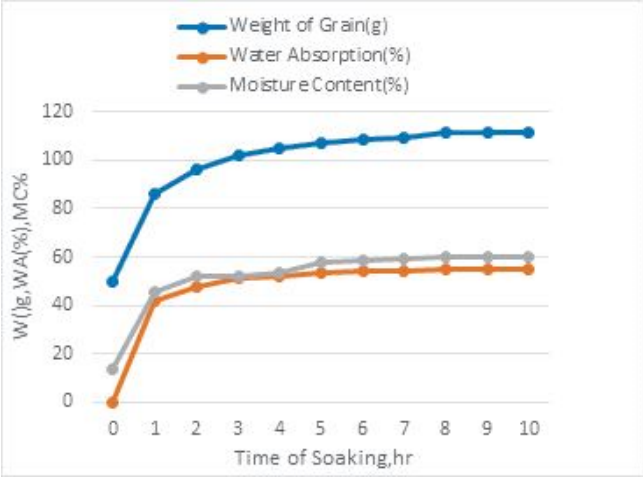

Fig. 2 : Effect of soaking time on weight of grain (gm), water absorption and Moisture content of soybean grain at 50°C.

From above data it is cleared that, at 50°C soaking water temperature, the moisture content of soybean grain increased from 15.51 % to 150.00% (Fig.2). The water absorption by the soybean grain is a diffusion process and is controlled by concentration gradient. According to fig. 2, the initial water uptake is high due to the high-water concentration gradient between the soaking medium and the dry soybean grains. The water absorption rate gradually decreased as the soaking process progressed due to a decrease in the water concentration gradient. According to Sayar and colleagues (2001) and Abu Ghannam and Mckenna (1997), this is due to water filling into the intercellular spaces. During the first hour of

Table 5 : Effect of Soaking time on soybean grains at 50°C.

Hours (Hrs)	Initial weight of grains, gm	Final weight of grains, gm	Water Absorption, %	Moisture content, % wb	Moisture content, % db
0	50	50	-	13.43	15.51
1	50	86.23	42.02	45.87	84.74
2	50	96.02	47.93	51.77	107.33
3	50	102.03	50.99	52.32	108.57
4	50	104.98	52.37	53.16	113.49
5	50	107.23	53.37	58.15	138.94
6	50	108.59	53.96	58.69	142.07
7	50	109.52	54.35	59.16	144.85
8	50	111.42	55.12	60	150.00
9	50	111.42	55.12	60	150.00
10	50	111.42	55.12	60	150.00

Table 6 : Summary output weight of grain at 50 DC.

Regression Statistics								
Multiple R	0.7795							
R Square	0.6077							
Adjusted R Square	0.5641							
Standard Error	2.1898							
Observations	11							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	66.8417	66.8417	13.9388	0.0047			
Residual	9	43.1583	4.7954					
Total	10	110						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-9.1272	3.8411	-2.3762	0.0415	-17.8164	-0.4380	-17.8164	-0.4380
X Variable 1	0.1414	0.0379	3.7335	0.0047	0.0557	0.2271	0.0557	0.2271

soaking, the rate of water absorption was rapid. The moisture content (%, d.b) increased from the initial 15.51% to 84.74%. From the second hour to 8th hour of soaking water absorption was gradual and increased the moisture content to a maximum of 150.00% (d.b.). At the 8th hour the, moisture content remains same as 150.00% (d.b.). The similar trend was reported by Munu N, *et.al*. As the water absorption percentage remains same after 8th hour, the moisture ratios at the same hours remains constant. It shows in Fig. 2.

The statistical analysis is same as like the 40°C. But the time required is less as compared to 40°C.

Effect of Soaking time on soybean grains at 60°C

The effect of soaking time on soybean grains at 60°C is given in Table 7.

- The **F-statistic = 12.52** with a **p-value of 0.0076** indicates that the regression model is **statistically significant**. This means the independent variable **does significantly affect** the grain weight at the 60°C level, at the **1% significance level**.

Regression Coefficient

Coefficient	Estimate	Std. Error	t-Stat	P-value	95% CI
Intercept	-7.8281	3.5414	-2.21	0.0580	(-15.9947, 0.3384)
X Variable 1	0.1236	0.0349	3.54	0.0076	(0.0430, 0.2041)

Table 7 : Effect of Soaking time on soybean grains at 60°C.

Hours (Hrs)	Initial weight of grains, gm	Final weight of grains, gm	Water Absorption, %	Moisture content, % wb	Moisture content, % db
0	50	50	—	13.43	15.51
1	50	87.68	42.97	46.91	88.83
2	50	96.23	48.04	51.89	107.85
3	50	103.79	51.83	53.19	113.62
4	50	107.27	53.39	54.2	118.34
5	50	108.59	53.96	58.8	142.71
6	50	109.98	54.54	59.33	145.88
7	50	111.42	55.12	60	150.00
8	50	111.42	55.12	60	150.00
9	50	111.42	55.12	60	150.00

Table 8 : Summary output effect on weight of grain at 60 dc.

Regression Statistics								
Multiple R	0.78111							
R Square	0.61013							
Adjusted R Square	0.56139							
Standard Error	2.00513							
Observations	10							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	50.3356	50.3356	12.5196	0.0076			
Residual	8	32.1644	4.0206					
Total	9	82.5						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-7.8281	3.5414	-2.2104	0.0580	-15.9947	0.3384	-15.9947	0.3384
X Variable 1	0.1236	0.0349	3.5383	0.0076	0.0430	0.2041	0.0430	0.2041

- The **intercept** is not statistically significant at the 5% level ($p = 0.058$), but it's close, suggesting caution in interpretation.
- The **slope for X Variable 1 is significant** ($p = 0.0076$). This means that **for each one-unit increase in X**, the grain weight **increases by approximately 0.1236 units**, holding all else constant.

Conclusion / Remark Statement

The regression model demonstrates a statistically significant relationship between the independent variable and the weight of grain at 60°C, with **$F(1, 8) = 12.52$, $p = 0.0076$**. The model explains **61% of the variation** in grain weight. The slope coefficient (0.1236) is positive and significant ($p < 0.01$), indicating that as the independent variable increases, the weight of the grain also increases significantly. While the intercept is marginally insignificant ($p = 0.058$), the overall model fit and slope are robust.

Regression Analysis Summary: Water Absorption at 60°C

This regression analysis evaluates the relationship between an independent variable (X Variable 1) and water absorption at 60°C. The results, summarized in the ANOVA and coefficient tables, indicate a statistically significant relationship.

ANOVA Table Interpretation

Source	df	SS	MS	F	Significance F
Regression	1	37.6808	37.6808	6.7258	**0.0319**
Residual	8	44.8192	5.6024		
Total	9	82.5			

- The **F-statistic is 6.73** with a **p-value of 0.0319**, which is **less than 0.05**, indicating the model is statistically significant.
- This suggests that the predictor variable has a meaningful effect on water absorption at 60°C.

Regression Coefficients Table

Term	Coefficient	Std. Error	t Stat	P-value	95%CI Lower	95% CI Upper
Intercept	-1.1662	2.3095	-0.505	0.6272	-6.4919	4.1595
X Variable 1	0.1205	0.0465	2.593	**0.0319**	0.0134	0.2277

- The **slope (0.1205)** indicates that for every **1-unit increase in X**, water absorption at 60°C increases by **0.1205 units**, on average.
- The slope is statistically significant (**p = 0.0319**), confirming the predictive power of X Variable 1.
- The **intercept** is not statistically significant (**p = 0.6272**), meaning it does not significantly differ from zero in this context.

Model Fit Statistics

Statistic	Value
Multiple R	0.6758
R Square (R^2)	0.4567
Adjusted R Square	0.3888
Standard Error	2.3669
Number of Observations	10

- The **R^2 value of 0.4567** indicates that about **45.67% of the variability** in water absorption at 60°C is explained by the predictor.
- The **adjusted R^2 of 0.3888** accounts for model complexity and still supports a moderate explanatory power.

Conclusion/Remark

The regression model shows a **moderate but statistically significant** relationship between X Variable 1 and water absorption at 60°C. The model explains nearly **46% of the variance**, with the predictor having a **significant positive effect**. However, the unexplained variance suggests other influencing factors could improve the model. This analysis provides a strong foundation for further exploration or predictive modelling involving water absorption.

Regression Analysis Summary: MC/DB at 60°C

This regression model analyses the relationship between an independent variable (X Variable 1) and the moisture content or dry basis (MC/DB) at 60°C. The analysis reveals a strong, statistically significant relationship.

ANOVA Table Interpretation

Source	df	SS	MS	F	Significance F
Regression	1	60.9114	60.9114	22.5717	**0.0014**
Residual	8	21.5886	2.6986		
Total	9	82.5			

- The **F-statistic = 22.57** with a **p-value = 0.0014** is highly significant (**p < 0.01**).
- This indicates that the regression model is statistically significant, and the independent

Table 9 : Summary output water absorption at 60°C.

Regression Statistics								
Multiple R	0.6758							
R Square	0.4567							
Adjusted R Square	0.3888							
Standard Error	2.3669							
Observations	10							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	37.6808	37.6808	6.7258	0.0319			
Residual	8	44.8192	5.6024					
Total	9	82.5000						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-1.1662	2.3095	-0.5050	0.6272	-6.4919	4.1595	-6.4919	4.1595
X Variable 1	0.1205	0.0465	2.5934	0.0319	0.0134	0.2277	0.0134	0.2277

Table 10 : Summary output MC db at 60 deg celcius.

Regression Statistics								
Multiple R	0.8593							
R Square	0.7383							
Adjusted R Square	0.7056							
Standard Error	1.6427							
Observations	10							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	60.9114	60.9114	22.5717	0.0014			
Residual	8	21.5886	2.6986					
Total	9	82.5						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-2.8121	1.6244	-1.7312	0.1217	-6.5579	0.9337	-6.5579	0.9337
X Variable 1	0.0618	0.0130	4.7510	0.0014	0.0318	0.0918	0.0318	0.0918

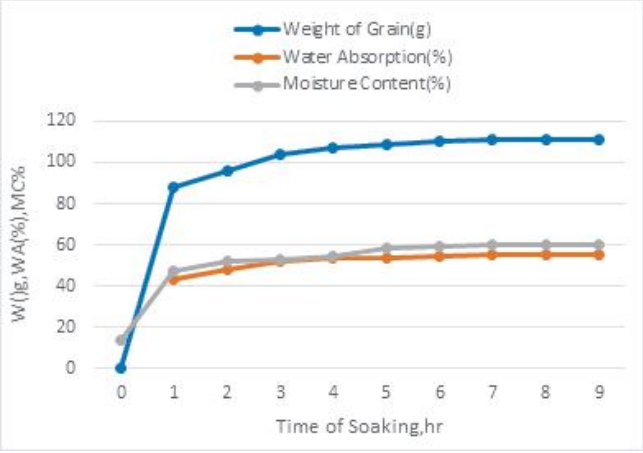

Fig. 3 : Effect of soaking time on weight of grain (gm), water absorption and Moisture content of soybean grain at 60°C.

variable reliably predicts the MC/DB at 60°C.

Regression Coefficients Table

Term	Coefficient	Std. Error	t Stat	P-value	95%CI Lower	95% CI Upper
Intercept	-2.8121	1.6244	-1.7312	0.1217	-6.5579	0.9337
X Variable 1	0.0618	0.0130	4.7510	**0.0014**	0.0318	0.0918

- The **coefficient for X Variable 1 is 0.0618**, meaning that for every 1-unit increase in the predictor, MC/DB increases by approximately **0.0618 units**.
- The **p-value = 0.0014** confirms this effect is **statistically highly significant**.
- The **intercept** is not statistically significant (*p = 0.1217*), which implies the intercept may not be meaningfully different from zero.

Model Fit Statistics

Statistic	Value
Multiple R	0.8593
R Square (R^2)	0.7383
Adjusted R Square	0.7056
Standard Error	1.6427
Number of Observations	10

- **R^2 = 0.7383** indicates that about **73.83% of the variability** in MC/DB at 60°C is explained by the predictor.
- The **adjusted R^2 = 0.7056** further supports a strong model fit, even after accounting for the number of predictors.

Conclusion and Remarks

The regression analysis reveals a **strong and statistically significant positive relationship** between the independent variable and MC/DB at 60°C. With an **R^2 of 73.83%**, the model demonstrates excellent explanatory power. The highly significant slope coefficient (*p = 0.0014*) confirms the predictor has a meaningful impact on the moisture content or dry basis. While the intercept is not statistically significant, the model overall is robust and suitable for predictive purposes or further analysis in related drying or material moisture studies.

From above data, it is cleared that, at 60°C soaking

water temperature, the moisture content of soybean grain increased from 15.51% to 150.00% (Fig. 2). The water absorption by the soybean grain is a diffusion process and is controlled by concentration gradient. According to Fig. 3, the initial water uptake is high due to the high-water concentration gradient between the soaking medium and the dry soybean grains. The water absorption rate gradually decreased as the soaking process progressed due to a decrease in the water concentration gradient. According to Sayar and colleagues (2001) and Abu Ghannam and Mckenna (1997), this is due to water filling into the intercellular spaces. During the first hour of soaking, the rate of water absorption was rapid. The moisture content (%, d.b) increased from the initial 15.51% to 88.83%. From the second hour to 7th hour of soaking water absorption was gradual and increased the moisture content to a maximum of 150.00% (d.b.). At the 7th hour the, moisture content remains same as 150.00% (d.b.). The similar trend was reported by Munu *et al*. (2016). As the water absorption percentage remains same after 8th hour, the moisture ratios at the same hours remains constant. It shows in Fig. 3.

From this study, it has been clear that for the preparation of soymilk, the soybean grains can be soaked at 40°C for 9 hours, 50°C for 8 hours and 60°C at 7 hours for hydration of whole soybean.

The statistical analysis is same as like the 40°C. But the time required is less as compared to 40°C.

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