Determination of the peak force of a potato tuber at the rod collision by means of finite element analysis

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**ABSTRACT**

Potato is exposed to different types of impact loads during harvest, sorting, and transportation. The large impact force between potato and rod-shaped machinery parts causes the potato damage and brings economic losses for the food industry. To obtain the impact force and its influencing laws between potato and rod, both theoretical analysis and finite element analysis (FEA) were used. By defining the impact force coefficient ($K$), a mechanical model between the peak impact force ($F_{\text{max}}$), potato mass ($m$), and drop height ($h$) was established. The FEA virtual experiments showed that $F_{\text{max}}$ was increased linearly with the increase in $m$, $h$, and $m\sqrt{h}$. When the potato mass was from 0.2 kg to 0.35 kg and the drop height was from 0.2 m to 0.3 m, the regression equation between $F_{\text{max}}$ and $m\sqrt{h}$ had a similar structure to the mechanical model, which verified the theoretical analysis and allowed the assessment of potato impact force. The results of this article can contribute to predicting the impact force of potato and solving other problems of solid-like agricultural materials related to impact.

**Introduction**

In the process of mechanized harvesting, the potato impact damage is caused by collision between potatoes and harvesting device, which seriously affects its sales and storage, and brings great economic losses to the potato industry.\(^{[1–3]}\) What is more, impact damage of potato is the common phenomenon in the phase of harvesting, sorting, grading, and packing.\(^{[4]}\) The collision between potato and mechanical parts produces large impact force, which causes the potato damage directly. Therefore, it is important to study the influencing factors of potato impact damage and the mechanical model of potato impact force to reduce the potato damage and improve the level of potato harvest technology.

The research on potato damage has been started long ago and attracted the attention of many scholars.\(^{[5,6]}\) At present, there are many related studies on the research of potato damage and collision characteristics\(^{[7–9]}\). Classically, experimental studies on impact damage of potato are mainly investigated through pendulum experiments or drop experiments.\(^{[6,10–13]}\) The influence factors of potato impact damage mainly include drop height, potato mass, potato tuber temperature, collision material, potato variety, and cultivation conditions.\(^{[4]}\) And the damage evaluation indexes mainly include collision pressure, acceleration, potato damage volume, damage area, damage depth, and respiratory rate.\(^{[14]}\) Because of the special shape of the collision body and the short impact contact time, it is difficult to test the impact force between potato and rod through the experimental method. Finite element analysis (FEA) is a successful analysis tool for developing approximate solutions to complex engineering problems and is very popular.\(^{[15]}\) Therefore, the FEA method is more preferred by researchers to study the related problems of potato impact damage.

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Cerruto used the FEA method to simulate the collision between spherical potato and steel plate and analyzed the effects of potato elastic modulus, density, mass, drop height, and sphere diameter on the impact force and acceleration.\cite{16} Caglayan used ANSYS Workbench to analyze the characteristics of impact contact stress and displacement during the collision between potato and steel plate.\cite{17} Celik studied the stress changes during the free fall collision between potato and potato pile, which provided an operation guide for similar studies.\cite{15} Nikara established the collision models of potato tubers and cells and studied the macro and micro damage of potatoes based on LS-DYNA.\cite{18} Gao studied the response of potato after collision with rigid plate from three different heights based on FEA method and five response parameters of contact time, impact peak force, peak force time, maximum deformation, and coefficient of restitution were analyzed.\cite{19} What is more, there have been many studies on the construction of the exact geometry of the 3D model\cite{20,21} and how to solve the impact damage to pears, apples, peaches, and tomatoes using the FEA method.\cite{22–25}

Based on the above literature analysis, most research works on potato impact damage are mainly based on experimental test and FEA method. There are few theoretical studies on the impact force between potato and rod. The theoretical model of potato impact force is unknown. At present, there are few studies on the mathematical model between impact force, drop height, and potato mass, so it is difficult to predict the impact force under different conditions. Therefore, this article aims to establish a mechanical model of the impact force between potato and rod and to analyze the factors and laws which affect the impact peak force of potatoes. The theoretical model and regression equation obtained in this study provide a theoretical basis and mathematical formula for the analysis and prediction of impact force between potato and rod in the harvest process, which is important to the study of potato impact damage.

**Material and methods**

**Development of impact force model**

Potato is a viscoelastic body, and the viscoelastic deformation occurs during the process of potato colliding with the rod of potato soil separating screen.\cite{25,26} The impact mechanical model between potato and rod is shown in Figure 1.\cite{4,27} The parameters of $m$, $k$, and $c$, respectively, represent the potato mass, the elastic coefficient, and the viscous damping coefficient.

When the potato collides with the rod at the speed of $V_0$, the differential equation of the collision process is obtained as follows:\cite{4}

$$m\ddot{y}(t) + c\dot{y}(t) + ky(t) = 0 \tag{1}$$

where $m$ is the potato mass, and the parameters of $y(t)$, $\dot{y}(t)$, and $\ddot{y}(t)$ represent the collision deformation, speed and acceleration of potato; $k$ is the elastic coefficient; $c$ is the viscous damping coefficient; and $t$ is the contact time. To solve Eq. (1), three parameters of $\omega_n$, $\xi$, and $\omega_d$ are defined as follows:\cite{4}

$$\omega_n = \sqrt{\frac{k}{m}}$$

$$\xi = \frac{c}{2\sqrt{mk}} \tag{2}$$

$$\omega_d = \omega_n\sqrt{1 - \xi^2}$$
where $\omega_n$ is the natural angular frequency of the undamped system, $\xi$ is the damping ratio, and $\omega_d$ is the natural angular frequency of the damped system. Since the potato and rod will be separated after collision, it can be considered that the impact mechanical model shown in Figure 1 is an underdamped system.\(^4\) Therefore, $\xi$ satisfies the condition of $0 < \xi < 1$. At the beginning of the collision process, both $t$ and $y(t)$ are zero, and $\dot{y}(t) = V_0$. So the general solution of Eq. (1) is

$$y(t) = \frac{V_0}{\omega_d} e^{-\xi \omega_d t} \sin(\omega_d t)$$

(3)

where $V_0$ is the initial collision speed of potato. The derivative of Eq. (3) can be obtained as follows:

$$\dot{y}(t) = \left[V_0 \cos(\omega_d t) - \frac{V_0 \xi}{\sqrt{1 - \xi^2}} \sin(\omega_d t)\right] e^{-\xi \omega_d t}$$

(4)

According to Eqs. (1)–(4), the impact force between potato and rod can be obtained.

$$F = m \omega_n V_0 \frac{1 - 2\xi^2}{\sqrt{1 - \xi^2}} \sin(\omega_d t) + 2\xi \cos(\omega_d t) e^{-\xi \omega_d t}$$

(5)

where $F$ is the impact force. Equation (6) is derived from Eq. (5) by merging the trigonometric functions.
\[ F = m \omega_n V_0 \frac{1}{\sqrt{1 - \xi^2}} \sin(\omega_d t + \alpha) e^{-\xi \omega_d t} \]  \hspace{1cm} (6)

where \( \alpha \) is the phase angle. \( \alpha \) can be obtained by Eq. (7):

\[ \tan \alpha = \frac{2 \xi \sqrt{1 - \xi^2}}{1 - 2 \xi^2} \]  \hspace{1cm} (7)

To solve the maximum value of the impact force, the derivative of Eq. (6) is obtained. And when the derivative is zero, Eq. (8) can be obtained

\[ \xi \sin(\omega_d t + \alpha) - \sqrt{1 - \xi^2} \cos(\omega_d t + \alpha) = 0 \]  \hspace{1cm} (8)

Equation (9) is derived from Eq. (8) by merging the trigonometric functions.

\[ \sin(\omega_d t + \alpha + \beta) = 0 \]  \hspace{1cm} (9)

where \( \beta \) is the phase angle. \( \beta \) can be obtained by Eq. (10)

\[ \tan \beta = -\frac{\sqrt{1 - \xi^2}}{\xi} \]  \hspace{1cm} (10)

According to Eq. (9), the derivative of Eq. (6) will be zero when \( t = \frac{n \pi - (\alpha + \beta)}{\omega_d} \), where \( n \) is an integer. Therefore, the impact force will be the maximum. According to the expression of \( t \) and Eq. (6), the impact peak force can be obtained.

\[ F_{\max} = \frac{m \omega_n V_0}{\sqrt{1 - \xi^2}} |\sin \beta| e^{\frac{-\xi}{\sqrt{1 - \xi^2}} [n \pi - (\alpha + \beta)]} \]  \hspace{1cm} (11)

where \( F_{\max} \) is the impact peak force. According to Eq. (10), \( \sin \beta \) can be obtained.

\[ \sin \beta = -\sqrt{1 - \xi^2} \]  \hspace{1cm} (12)

Equation (13) is derived based on Eqs. (11) and (12).

\[ F_{\max} = m \omega_n V_0 e^{\frac{-\xi}{\sqrt{1 - \xi^2}} [n \pi - (\alpha + \beta)]} \]  \hspace{1cm} (13)

When the potato drops onto the surface of the separating screen from a certain height and collides with the rod, the initial collision speed \( V_0 \) satisfies the following equation:

\[ V_0 = \sqrt{2gh} \]  \hspace{1cm} (14)

where \( h \) is the drop height of potato; \( g \) is the standard earth gravity. Equation (15) is obtained according to Eqs. (13) and (14)

\[ F_{\max} = m \omega_n \sqrt{2gh} e^{\frac{-\xi}{\sqrt{1 - \xi^2}} [n \pi - (\alpha + \beta)]} \]  \hspace{1cm} (15)

Based on the above equations, the impact peak force of potato colliding with the rod is related to the potato mass, drop height, \( \omega_n, \xi, \alpha, \) and \( \beta \). To simplify Eq. (15), the impact force coefficient is defined as follows:

\[ K = \omega_n \sqrt{2gh} e^{\frac{-\xi}{\sqrt{1 - \xi^2}} [n \pi - (\alpha + \beta)]} \]  \hspace{1cm} (16)

where \( K \) is the impact force coefficient. Therefore, Eq. (17) is obtained based on Eqs. (15) and (16)

\[ F_{\max} = Km \sqrt{h} \]  \hspace{1cm} (17)
Both the elastic coefficient and viscous damping coefficient are related to the potato varieties and collision process. When the potato mass, variety, drop height, and collision body structure are determined, $\omega_n$, $\zeta$, $\alpha$, and $\beta$ will be determined. Therefore, the impact force coefficient and the impact peak force can be obtained.

**Finite element analysis of potato collision process**

To obtain the impact peak force and force coefficient of potato under different conditions, the collision process between potato and rod was analyzed by LS-DYNA in workbench 19.2. The point cloud data of a typical potato was obtained by a 3D scanner (VTOP100, Tianjin Weishen Technology Co., Tianjin, China), and then the potato 3D solid model was established based on the surface modeling method.\(^{[28]}\) According to the structure of potato soil separation device of a potato harvester, a simplified three-dimensional model of the separation screen was established. Finally, an assembly model of the potato and separation screen was established in SolidWorks.

During the FEA process, potato was regarded as a nonlinear body. The modulus of elasticity of potato was 3.35 MPa\(^{[28]}\) and Poisson’s ratio was 0.49.\(^{[15,17]}\) The potato yield strength was 0.8776 MPa and tangent modulus was 0 MPa.\(^{[28]}\) During the collision process, the potato was regarded as a flexible body, and the rod was regarded as a rigid body with fixed constraints. The modulus of elasticity of the rod was 206 GPa and Poisson’s ratio was 0.3. The static and dynamic friction coefficient between potato and rod were 0.31 and 0.21, respectively.\(^{[29]}\) The standard earth gravity and potato drop height were set as the initial collision conditions. The FEA calculation time was 15 ms, and the output was set to 60 equal interval results. After preprocessing, the K file was generated and solved by LS DYNA solver and post processed by LS Prepost 4.5. A Lenovo desktop computer (Intel Core i5-4460 CPU @ 3.20 GHz, NVIDIA GeForce GT 750, and RAM: 4 GB) was used as the solving platform. The physical structure of potato soil separation screen, the impact model of potato and rod, and the FEA mesh parameters\(^{[28]}\) were shown in Figure 2.

**Virtual simulation test**

The single factor virtual simulation test was designed based on the FEA method. The test factors were potato mass and drop height. The potato variety was FuRuiTe, which was widely planted in the Inner Mongolia Autonomous, China. The range of potato mass was referenced by the typical mass of a single potato, which was mostly about 0.25 kg. The range of potato

![Figure 2](image-url). Structure of potato soil separating screen, FEA models, and mesh parameters.
drop height was determined according to the drop of potatoes from the lifting chain to the separation screen in the process of mechanized harvesting, which was usually between 0.25 m and 0.3 m.

To obtain the mathematical model of potato impact peak force and predict the force values under certain conditions, four potato masses and three drop heights were combined to obtain 12 FEA combinations. The impact peak force ($F_{\text{max}}$) between potato and rod was taken as the evaluation index. The impact force coefficient ($K$) was solved according to Eq. (17) when the potato mass, drop height, and $F_{\text{max}}$ were obtained. The virtual simulation test scheme and results were shown in Table 1.

| FEA number | Potato mass (m) /kg | Drop height (h) /m | $F_{\text{max}}$ /N | $K$   |
|------------|---------------------|-------------------|---------------------|-------|
| 1          | 0.15                | 0.30              | 218.16              | 2655.36 |
| 2          | 0.20                | 0.30              | 260.06              | 2374.01 |
| 3          | 0.25                | 0.30              | 298.48              | 2179.79 |
| 4          | 0.30                | 0.25              | 331.88              | 2019.76 |
| 5          | 0.35                | 0.20              | 370.23              | 1931.27 |
| 6          | 0.25                | 0.15              | 196.86              | 2033.16 |
| 7          | 0.25                | 0.20              | 233.95              | 2092.51 |
| 8          | 0.20                | 0.20              | 266.91              | 2135.28 |
| 9          | 0.30                | 0.30              | 298.48              | 2179.79 |
| 10         | 0.35                | 0.30              | 326.67              | 2208.69 |
| 11         | 0.20                | 0.20              | 203.96              | 2280.34 |
| 12         | 0.25                | 0.20              | 233.95              | 2092.51 |
| 13         | 0.30                | 0.20              | 261.28              | 1947.47 |
| 14         | 0.35                | 0.20              | 287.52              | 1836.90 |
| 15         | 0.20                | 0.25              | 233.15              | 2331.50 |
| 16         | 0.25                | 0.25              | 266.91              | 2135.28 |
| 17         | 0.30                | 0.25              | 299.05              | 1993.67 |
| 18         | 0.35                | 0.25              | 328.27              | 1875.83 |
| 19         | 0.20                | 0.30              | 260.06              | 2374.01 |
| 20         | 0.25                | 0.30              | 298.48              | 2179.79 |
| 21         | 0.30                | 0.30              | 331.88              | 2019.76 |
| 22         | 0.35                | 0.30              | 370.23              | 1931.27 |

Figure 3. FEA results for the simulation of FEA number 15.
According to the FEA parameters setting and test scheme in Table 1, the impact force between potato and rod was obtained. The typical curve of impact force and contour of the von Mises stress were shown in Figure 3. It was showed that with the change in contact time, the impact force changed continuously. The maximum value of the impact force curve was the impact peak force. The rod in contact with the potato was hidden in order to show the stress contour of the contact area more clearly.

**Results and discussion**

**Correlation analysis between the simulation factors and results**

To determine the relationships between the simulation factors and results, the virtual simulation test data in Table 1 were imported into Statistical Product and Service Solutions (SPSS 19.0) and discussed by using Pearson’s correlation analysis. The correlation coefficient and significance results were shown in Table 2. It was found that all the simulation factors \((m, h, \text{ and } m\sqrt{h})\) were significantly correlated with the results \((F_{\text{max}} \text{ and } K)\). Therefore, for in-depth study of potato impact force, the linear fitting equations between the simulation factors and results can be found to predict the results of \(F_{\text{max}} \text{ and } K\) accurately.

**Effect of potato mass on the impact peak force and force coefficient**

The graph of impact peak force and potato mass was drawn based on the results in Table 1, as shown in Figure 4. The impact peak force increased with the increase in potato mass. When the potato mass was from 0.15 kg to 0.35 kg, the impact peak force rose from 218 N to 370 N (fluctuation amplitude: 152 N). It was because the larger potato mass caused the larger impact impulse so that the impact peak force increased correspondingly. The fitting line showed that the relationship between the impact peak force and potato mass was linear.

Deng\(^{[30]}\) made the potato collide with the force hammer and the results showed that the impact peak force increased linearly with the increase in potato mass. When the drop height was 0.06 m and potato mass was increased from 0.1 kg to 0.3 kg, the impact peak force increased from 40 N to 110 N. Geyer\(^{[12]}\) conducted the collision test for two types of potatoes (Afra and Milva) free dropping from a height of 0.25 m onto a steel plate. Results showed that with the increase in the potato mass from 0.11 kg to 0.2 kg, the impact peak force rose from 220 N to 325 N for ‘Afra,’ and from 190 N to 310 N for ‘Milva.’ Cerruto\(^{[16]}\) performed similar collisions with Geyer’s test based on the FEA and the simulations results showed that the impact peak force ranged from 198 N to 325 N. Both the results of Geyer’s test and Cerruto’s simulation analysis were higher than the results of this article. It was because of the differences of potato varieties, collision body structures, and the tilt angle of the rod. In the similar simulation conditions (the rod diameter was 11 mm and the tilt angle was 14.4°), the impact peak force was about 234 N when the potato mass was 0.25 kg and the drop height was 0.2 m,\(^{[27]}\) which was very close to the results of this article.

**Table 2. Correlation coefficient and significance results between simulation factors and results.**

| Simulation factors | \(F_{\text{max}} \text{ N} \) | \(K \) |
|--------------------|-------------------------------|-------|
| \((m) /kg\)        | Correlation coefficient | P value | ** | Correlation coefficient | P value | ** |
| Potato mass        | 0.999                        | 0      | ** | −0.981                 | 0.002 | ** |
| Drop height \((h)/m\) | 0.999                        | 0      | ** | 0.993                  | 0      | ** |
| Combination of \(m\) and \(h\) \((m\sqrt{h}) /kg \cdot m^{1/2}\) | 0.961                        | 0      | ** | −0.819                | 0.001 | ** |

\(\ast\) represents extremely significant \((p < 0.01)\).
In the process of potato mechanized harvesting, the impact force is one of the main causes of potato damage. Covering appropriate buffer materials on the rod of potato soil separation device or selecting the potato varieties with medium weight in potato breeding can effectively reduce the impact force and damage rate of potatoes.

The relationship between the potato mass and impact force coefficient was shown in Figure 5. With the increase in potato mass, the impact force coefficient decreased gradually. According to Eq. (2), $\omega_n$ and $\xi$ would decrease with the increase in potato mass when both the elastic coefficient and viscous damping coefficient of the potato were determined. Therefore, the impact force coefficient would be smaller according to Eq. (16). The fitting equation showed that the impact force coefficient was linear.
with the potato mass, and $R^2$ was 0.9623. When the potato mass was between 0.15 kg and 0.35 kg and the drop height was 0.3 m, the impact force coefficient can be obtained according to the fitting equation. Then, the impact peak force can also be obtained according to Eq. (17), and it can help to predict the damage of potato after collision.

**Effect of drop height on the impact peak force and force coefficient**

The relationship between the impact peak force and drop height was shown in Figure 6. When the potato mass was 0.25 kg and the drop height increased from 0.15 m to 0.35 m, the impact peak force rose from about 197 N to 327 N (fluctuation amplitude: 152 N). The fitting equation showed that the impact peak force was linear with the drop height, and $R^2$ was 0.9975. When the potato mass was constant, the potato speed would increase with the increase in drop height. Therefore, the impact peak force in the collision process increased.

Both Geyer\textsuperscript{[12]} and Cerruto\textsuperscript{[16]} found that the potato impact peak force increased with the increase in drop height, which was consistent with the results of this article. Praeger\textsuperscript{[31]} found that the impact peak force was about 180 N when a 0.22 kg potato dropped from a height of 0.1 m and collided with a steel plate. In this article, the impact peak force of a 0.25 kg potato dropping onto the rod from a height of 0.15 m was 196.86 N. Compared with Praeger’s test results, the increase in potato mass and drop height caused the increase in the impact peak force. Based on the FEA simulation, Gao found that when a 0.178 kg potato was dropped from a height of 0.2 m onto a rigid plate, the average impact peak force was about 280 N.\textsuperscript{[19]} The difference of the simulation results was caused by the different structure of the collision body and the tilt angle of the rod.

The impact peak force increased linearly with the increase in the potato drop height, which makes the potato damage more serious. Reasonably adjusting the structural and working parameters of the potato harvester can reduce the relative drop height of potato on the separation screen, which can effectively reduce the potato damage in the harvest process.

The relationship between potato drop height and impact force coefficient was shown in Figure 7. With the increase in drop height, the impact force coefficient increased gradually. According to Eq. (16), the impact force coefficient was mainly related to $\omega_n$ and $\xi$. $\omega_n$ was determined by the potato mass

![Figure 6](image-url) **Figure 6.** Relationships between $F_{\text{max}}$ and $h$. 
and elastic coefficient and was less affected by the drop height. Xie\textsuperscript{[4]} found that with the increase in the drop height, the viscosity of potatoes gradually increased during the collision. Therefore, the impact force coefficient increased correspondingly. According to the data in Table 1, when the potato mass increased from 0.15 kg to 0.35 kg, the average of the impact force coefficient was 2232.04 and the standard deviation was 290.52. When the drop height increased from 0.15 m to 0.35 m, the average of the impact force coefficient was 2129.89 and the standard deviation was 69.79. Compared with the drop height, potato mass had a greater effect on the fluctuation range of the impact force coefficient.

The fitting equation showed that the impact force coefficient was approximately linear with the drop height of potato, and $R^2$ was 0.9862. When the potato mass was 0.25 kg and the drop height was from 0.15 m to 0.35 m, the impact force coefficient could be obtained according to the fitting equation. Then, the impact peak force between potato and rod can be solved according to Eq. (17).

\textbf{Effect of the combination of potato mass and drop height on the impact peak force and force coefficient}

According to the results of the FEA number 11 to 22 in Table 1, factors of potato mass and drop height were combined in the form of $m\sqrt{h}$. The graph of potato impact peak force was drawn, as shown in Figure 8. With the increase in $m\sqrt{h}$, the impact peak force increased linearly. When the potato mass was from 0.2 kg to 0.35 kg and the drop height was from 0.2 m to 0.3 m, $F_{max}$ and $m\sqrt{h}$ approximately conformed to the following equation:

\begin{equation}
F_{max} = 1453.3m\sqrt{h} + 82.068
\end{equation}

Equation (18) had a similar structure to Eq. (17), which verified that the theoretical model of impact peak force was consistent with the simulation analysis results. Deng\textsuperscript{[30]} found through the test that when the potato mass was from 0.1 kg to 0.3 kg and the drop height was from 0.02 m to 0.1 m, the regression equation of the impact peak force between the potato and impact hammer with a steel tip was as follows:

\begin{equation}
F_{max} = 1277.84m\sqrt{h}
\end{equation}
The difference between Eqs. (19) and (18) was mainly due to the different range of potato mass and drop height, and the different material and structure of the collision body.

The graph between the impact force coefficient and \( m\sqrt{h} \) was shown in Figure 9. Overall, the impact force coefficient decreased with the increase in \( m\sqrt{h} \). The variation laws and fitting equations for the curves of ①, ②, ③, and ④ in Figure 9 showed that when the potato mass was constant, the impact force coefficient increased linearly with the increase in drop height. When the drop height was from 0.2 m to 0.3 m, the minimum value of the impact force coefficient on the curve with the smaller potato mass was greater than that of the maximum value on the curve with the larger potato mass. It indicated that the change in potato mass had a greater effect on the impact force coefficient than that of the drop height. The curves of ⑤, ⑥, and ⑦ in Figure 9 showed that when the drop height was constant, the impact force coefficient decreased linearly with the increase in potato mass.
According to the fitting equations and the grid of the impact force coefficient enclosed by the seven curves in Figure 9, the impact force coefficient can be predicted when the potato mass was from 0.2 kg to 0.35 kg and the drop height was from 0.2 m to 0.3 m. Then, the impact peak force between potato and rod can be obtained according to Eq. (17).

Conclusion

The impact force produced by the collision between potato and harvesting device has an important impact on potato damage. In this article, the collision between potato and rod of the potato soil separation device was studied. The mechanical model of impact peak force was established through the theoretical analysis, and both the impact peak force and force coefficient were obtained based on the FEA virtual simulation test. Results showed that the impact peak force increased linearly with the increase in potato mass and drop height. The impact force coefficient decreased linearly with the increase in potato mass and increased linearly with the increase in drop height. When the potato mass was from 0.2 kg to 0.35 kg and the drop height was from 0.2 m to 0.3 m, the mathematical equation of the impact peak force was obtained. This article provides an effective mechanical model for the study and prediction of the impact force between potato and rod and also provides a reference for the collision analysis of other solid-like agricultural materials. Future research works should further develop these findings through experiment tests and explore the mathematical relationship between the impact peak force and potato damage.

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