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MARKET SURVEY, FORCE CALCULATION AND TESTING OF GARLIC ON INNOVATIVE FORCE CALCULATING MACHINE

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Abstract – This paper presents the market survey related to garlic, its types and weight of garlic clove, garlic bulb and also the number of garlic clove included in the garlic bulb according to its type and weight. Also this paper presents he technique of calculating the various forces related to garlic like peeling force, breaking force, crushing force etc. In this paper, also it mention about the young's modulus of garlic and these technique is also useful for other types of products like ground nut, onion, almond, coconut etc. These are based on a systematic study of the garlic peeling process and testing of a prototype model of force instrument.

Keywords – Garlic peeling force, force instrument, young's modulus of garlic, garlic breaking force, garlic crushing force, types of garlic, and weight of garlic.

INTRODUCTION

Garlic is the most important foreign exchange earning spicy vegetable crop, commercially grown in India. India is one of the leading Garlic producing countries. Garlic has digestive, carminative and anti-rheumatic properties. It is used in Ayurveda formulation since ancient times for curing muscular pain, giddiness, lungs, heating intestinal ulcer, etc. Garlic is consumed as green as well as dried in the spice form and as ingredient to flavor the various vegetarian, non-vegetarian dishes and pickles. Good tasty pickles, chutneys, curry powders are prepared from Garlic cloves.

Very little work has been done on the garlic peeling and it is restricted to traditional peeling methods only. Traditional peeling methods viz.; hand peeling, f1ame peeling, oven peeling and chemical peeling are being used in processing industries, big restaurants, hotels and kitchens. These are laborious, time consuming, cost intensive and restrict speed of processing activity. Because of its typical shape, the mechanical peeling of garlic is still untouched by process engineers. Keeping this in view, a study was undertaken with the main objective of development of a garlic peeler.

The paper gives the information about the types of garlic and its weight which is available in Indian market. Also the paper gives the information about the method of calculation of force required to peel the garlic and also its force calculating machine and about young's modulus of garlic clove.

MARKET SURVEY

- **TYPES OF GARLIC**

According to market survey and observation, we can categorized the garlic broadly in three type

1. Single clove garlic
2. Multi clove garlic
3. Himalayan garlic

1. Single Clove Garlic

In single clove garlic, there is only a clove in garlic bulb. Its weight ranges between 5gm-10gm and its cost in market is near about 500 Rs. /Kg.

It is generally used for medical purpose in "AYURVED".

2. Multi Clove Garlic

It is a type of garlic which is plenty available in market. It is used mainly in food product. Its weight ranges between 12gm-35gm.

3. Himalayan Garlic

Himalayan garlic is a subtype of multi clove garlic. According its name, its production is taken in Himalayan area. If we compare Himalayan garlic with the other types of garlic, the Himalayan garlic is greater in size, shape and weight.

Its weight is near about 100gm. It contains 12-15 cloves in single garlic bulb which has weight up to 10gm.

- **WEIGHT OF GARLIC**

1. **Single Clove Garlic**
   Weight, W = 5gm to 10gm; (Single Clove)
2. **Multi Clove Garlic**
   i. Bulb Weight, W = 30gm to 35gm ; (Maximum)
      No. of Clove = 26 to 30
      Weight of single Clove = 1gm to 1.25gm
   ii. Bulb Weight, W = 25gm to 30gm
      No. of Clove = 22 to 26
      Weight of single Clove = 1gm to 1.25gm
   iii. Bulb Weight, W = 20gm to 25gm
      No. of Clove = 18 to 22
      Weight of single Clove = 1gm to 1.25gm
   iv. Bulb Weight, W = 16gm to 20gm
      No. of Clove = 14 to 18
      Weight of single Clove = 1gm to 1.25gm
   v. Bulb Weight, W = 12gm to 15gm ; (Minimum)
      No. of Clove = 10 to 14
      Weight of single Clove = 1gm to 1.25gm
3. **Himalayan Garlic**
   Weight up to, W = 100gm
   No. of Clove = 12 to 15
   Weight of Single Clove = Up to 10gm

FORCE CALCULATION

For finding or calculating the breaking force of garlic bulb, peeling force of garlic clove and crushing force of garlic clove, I developed the force instrument by using the spring, plates and nut and bolts which is work on the principle of," the applied force on the spring is the product of a stiffness of that spring and its deflection in the direction of force applied."

For calculating the force, some experimentation is carried out by using the force instrument. The force instrument is consisting of the spring, two moving plate, and one fix plate and tightening nut. By using the formula $F = K \times X$ it is possible to

calculate the gradual force required to break or peel the garlic bulb or clove respectively. First garlic bulb or clove is fixed in between two movable plates. After fixing it, it is started to tighten the nut up to breaking the garlic bulb or breaking the cover of garlic clove. Then measuring the displacement and multiplying it with stiffness of spring it will get the gradual force required to break or peel the garlic bulb or clove respectively. Where, F is a gradual force required to break the garlic bulb or to peel the garlic clove, K is the spring constant and X is the displacement of the spring after tightens the nut.

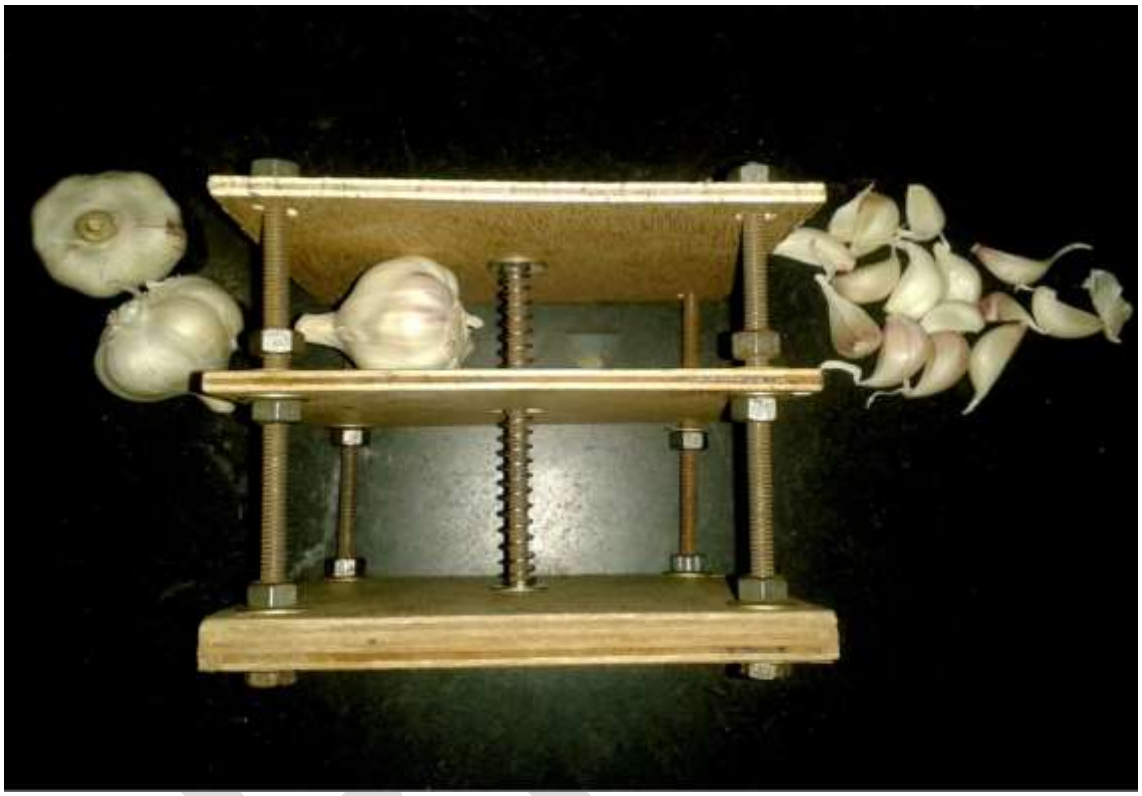

Fig. – Force Instrument

STIFFNESS OF SPRING

The "Stiffness" is the ratio of Load (W in Newton) per Deflection (X in mm). The stiffness is also known as "Spring Ratio" or "Spring Constant" and it is denoted by [K].

Therefore, **Stiffness, K = Load (W)/Deflection (X)**

For calculating the spring stiffness, we collect the following data.

Observation

Original length of spring, L = 95mm.

Weight, W			***Total Length, T_L, mm***	***Deflection, mm***	
gm	Kg	N		T_L – L	X
50	0.05	0.49	96	96 – 95	1
100	0.1	0.98	96.5	96.5 – 95	1.5
150	0.15	1.47	97	97 – 95	2
200	0.2	1.96	98	98 – 95	3
250	0.25	2.45	98.5	98.5 – 95	3.5
300	0.3	2.94	100	100 – 95	5
350	0.35	3.43	101	101 – 95	6
400	0.4	3.92	101.5	101.5 – 95	6.5
500	0.5	4.90	103	103 – 95	8
600	0.6	5.88	105	105 – 95	10
700	0.7	6.86	107	107 – 95	12

Table – Observation of Deflection of Spring

Now, using the equation,

Stiffness, K = Load (W)/Deflection (X)

Sample calculation of stiffness

From observation table taking a any value of force like 2.45 N and its respective value of deflection is 3.5 mm.

Weight W = 2.45 N

Deflection X = 3.5 mm

Therefore K_5 = W/X = 2.45/3.5 = 0.70 N/mm

Results

Sr. No. (K_n)	***W/X***	***Stiffness, N/mm***
K_1	0.49/1	0.49
K_2	0.98/1.5	0.65
K_3	1.47/2	0.74

K_4	1.96/3	0.65
K_5	2.45/3.5	0.70
K_6	2.94/5	0.59
K_7	3.43/6	0.57
K_8	3.92/6.5	0.60
K_9	4.90/8	0.61
K_{10}	5.88/10	0.59
K_{11}	6.86/12	0.57

Table – Stiffness of Spring

Now calculating the average stiffness of spring by using the equation

$K = (K_1+K_2+K_3+\ldots\ldots +K_n)/n$

Therefore Stiffness of Spring K,

K = (0.49+0.65+0.74+0.65+0.70+0.59+0.57+0.60+0.61+0.59+0.57)/11

K = 0.61 N/mm

So, now we have the value of stiffness of spring. So we can calculate the breaking force of garlic bulb, peeling as well as crushing force of garlic clove.

By using the force measuring instrument, now are calculate the force required to crush wet garlic clove, using following equation,

Crushing Force, F = K×X Newton

Where, K – Stiffness of spring, N/mm

X – Deflection of spring, mm

Observation during Experiment

Total length of spring, L_T = 95mm

Deflected length of spring, L_O = 81mm

∴ Deflection of spring, $X = L_T - L_O$

$X = 95 - 81$

∴ $X = 14$mm

∴ Crushing Force, F = 0.61×14

F = 8.54 N (Gradually Applied)

So, by using this force instrument and basic principle of it's working, we already calculate the range of breaking force of garlic bulb, force of peeling and crushing of garlic clove and these ranges are as follows,

- Force required to break the garlic bulb varies between
  F_{Break} = 4.88 N to 6.1 N
- Force required to peel the garlic clove varies between
  $F_{Peeling}$ = 1.83 N to 3.05 N
- Force required to crush the garlic clove varies between
  F_{Crush} = 7.32 N to 8.54 N

Also by using this force instrument we can calculate the force of breaking, peeling, crushing of other objects like ground nut, onion, almond, coconut and many more.

YOUNGS MODULUS OF GARLIC CLOVE

This force instrument is very useful for calculating the young's modulus of garlic. By using this force instrument we already calculate the young's modulus of garlic. And for that we perform the following experiments.

For calculating the modulus of elasticity we require the value of stress and strain developed in garlic. For that we first calculate the force and then by using the force and area we calculate the stress developed in a garlic pixel.

Also we have known the value of original length of garlic pixel and change in length of garlic pixel.

Fig. – Garlic Pixel

For calculating the young's modulus of garlic clove, following observation is done.

Stiffness, K = 0.61 N/m^2,

Force, F = K×X,

Dimension of garlic pixel = 7×7×13 mm,

Cross section area of garlic pixel, A = 4.9×10^{-5} m^2,

Stress developed in a garlic pixel, $\sigma = F/A$,

Deflection of a garlic pixel, $X = 95 - \delta_x$

Stress developed in a garlic pixel

Sr. No.	δ_x	***X, mm***	***F, N***	***σ, N/m²***
1	94.5	0.5	0.305	6224.5
2	94	1	0.61	12449.0
3	93.5	1.5	0.915	18673.5
4	93	2	1.22	24898
5	92.5	2.5	1.525	31122.4
6	92	3	1.83	37346.9
7	91.5	3.5	2.135	43571.4
8	91	4	2.44	49795.9
9	90.5	4.5	2.745	56020.4
10	90	5	3.05	62244.9
11	89.5	5.5	3.355	68469.4
12	89	6	3.66	74693.9

Table – Stress in Garlic Pixel

Original length of Garlic pixel = 13 mm,

l = Change in length

ΔL = Original length – Change in Length

$= L - l$

Strain, $\varepsilon = \Delta L/L$

Strain developed in a garlic pixel

Sr. No.	*L, mm*	*l, mm*	*ΔL, mm*	*ε*
1	13	12.5	0.5	0.03846
2	13	12	1	0.07692
3	13	11.5	1.5	0.11538
4	12	11	1	0.08333
5	11.5	10.5	1	0.08696
6	11	10	1	0.09091
7	10.5	9.5	1	0.09524
8	10	9	1	0.1
9	9.5	8.5	1	0.10526
10	9	8	1	0.11111
11	8.5	7.5	1	0.11765
12	8	7	1	0.12500

Table – Strain in Garlic Pixel

Up to Sr. No. 1 to 3 from stress and strain table, the respective values are in the elastic region and from Sr. No. 4 to 12; the values are in plastic region. Therefore, for finding the young's modulus taking the value up to Sr. No. 3.

Sample calculation of young's modulus

Young's modulus, $E = \text{stress/strain} = \sigma/\varepsilon$, N/m^2

Taking $\sigma_1 = 6224.5$ N/m2 from stress table and $\varepsilon_1 = 0.03846$ from strain table.

Therefore, $E_1 = \sigma_1/\varepsilon_1 = 6224.5/0.03846 = 1.62\times10^5$

Within elastic limit, the values of elasticity are as follows

$E_1 = 1.62\times10^5$ N/m^2

$E_2 = 1.62\times10^5$ N/m^2

$E_3 = 1.62\times10^5$ N/m^2

So from the above values we can conclude that the value of young's modulus of is E = 1.62×10^5 N/mm^2.

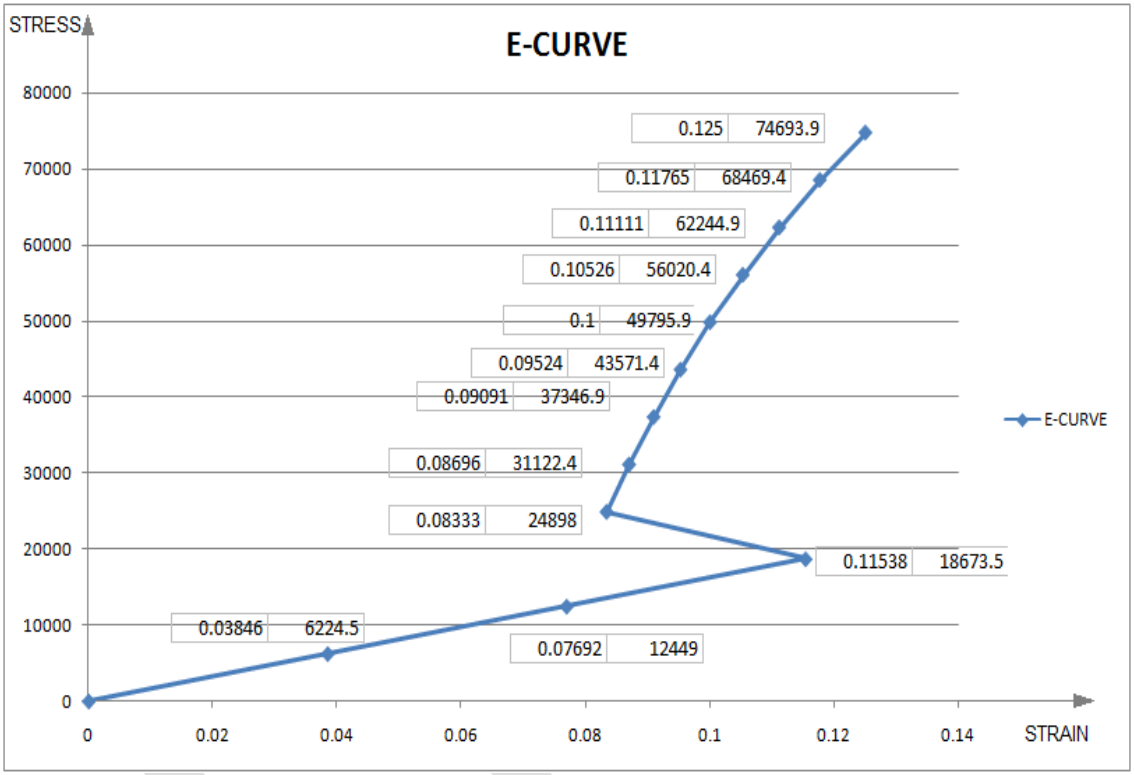

Fig. – Stress Strain Curve of Garlic Pixel

CONCLUSION

1. Thus the testing of garlic using innovative force calculating machine are as follows
   - Force required to break the garlic bulb varies between
     F_{Break} = 4.88 N to 6.1 N
   - Force required to peel the garlic clove varies between
     $F_{Peeling}$ = 1.83 N to 3.05 N
   - Force required to crush the garlic clove varies between
     F_{Crush} = 7.32 N to 8.54 N
2. Young's modulus of garlic calculated by using force calculating machine is equal to 1.62×10^5 N/m^2.

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