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Study of One Physical Property of Oil-Tea Camellia Heated by Microwave

Jian Zhou, Lijun LI, Zhiming Yang, Yei Xue and Shaobo Peng
Machinery and Electrical Engineering College of Centre South University of Forestry and Technology, Changsha, 410004, P.R. China

Abstract: In this study, we have a research of the physical properties of oil tea camellia fruit, which is one of the important and native ecological plants in China. One important physical property was studied; it was one crack type of oil-tea camellia fruit while heated by microwave. The fruit's diameters, quality, crack lengths were measured and fruit crack pictures in different time were taken in the heated process, the results showed that about 38% crack type was near -120º and the crack was produced almost at the time after it was heated about 60 sec. So the microwave heating method is more rapid to separate the oil-tea camellia fruit and seeds than other traditional methods. The theory of crack was also analyzed, formula relation of K_{ic} and E was obtained after calculated.

Keywords: Microwave, near-120º-crack type, oil-tea camellia fruit, physical property

INTRODUCTION

Oil tea tree, also called camellia plant, is an evergreen small arbor and one of the important plants in China. It is a species with a wide ecological breadth. It mainly grows in the hilly and mountainous regions between 18 and 34 of northern latitude and 1000 and 1220 of eastern longitude and with an elevation between 100 and 800 m. The trees have brown skins and are hard in quality and texture. The oval asymmetrical leaves are green in all seasons and have no apparent meshwork on the back. The tea oil trees have a long growth cycle. Each year they bloom in late october. The flowers (both male and female) mostly are white without handles, the florescence is two to three months, the fruits ripen in next october, the flowers coexist with the fruits to fully absorb natural nutrition and essence. In folk words, it is "holding a baby while becoming pregnant". The oil tree fruits are global, peach-chaped, orange-shaped, olived-shaped, or chicken-heart-shaped capsules. Inside the fruit skin with floss and there are many triangular or diamond brown luster seeds. Since oil tea trees grow in regions far from urban "three-waste" pollution sources and free from pollution of fertilizer or pesticides, so the oil extracted from fruits are genuine green edible vegetable oil (Xiao *et al*., 2006). Oil-tea camellia fruit is combined with camellia shell and camellia seeds, it's usually seperated by sunshine on the sunny days in china, so it is a new kind method seperating camellia shell from camellia seeds by microwave (Lijun *et al*., 2011).

In this study, we have a research of the physical properties of oil tea camellia fruit, which is one of the important and native ecological plants in China. One important physical property was studied; it was one crack type of oil-tea camellia fruit while heated by microwave. It is urgent to understand more physical properties of oil tea camellia fruit, such as its' cracking characteristic, properties of near-120º kind crack were studied in the experiments. The theory of crack was also analyzed, formula relation of KIC and E was obtained after calculated.

MICROWAVE HEATING SYSTEM

Midea microwave stove made in China, style KD21B/C-AN(B), volume 21L, microwave output power 800 W, microwave working frequency 2450 MHZ, the stove was transformed. Thermocouple thermometer was used for measuring the camellia surface temperature, made in Japan, style was OPTEX PT-303; for measuring the inner temperature of camellia fruit, temperature sensor of SG series micro hot resistance was adopted, model number was PT100, the measuring temperature range was -200-500°C. In the measured process, the thermocouple thermometer was well shielded. Set of measured liquid heat was below the microwave resonant chamber; it was designed and manufactured for measuring specific heat capacity of camellia fruit, shell and seed.

Measuring inner and surface temperature of oil tea camellia fruit heated by microwave: For measuring the inner and surface temperature of oil tea camellia fruit heated by microwave, shielded thermocouples were used to determine inner temperature of camellia fruit, three group samples' sizes, qualities and relative

Corresponding Author: Jian Zhou, Machinery and Electrical Engineering College of Centre South University of Forestry and Technology, Changsha, 410004, P.R. China

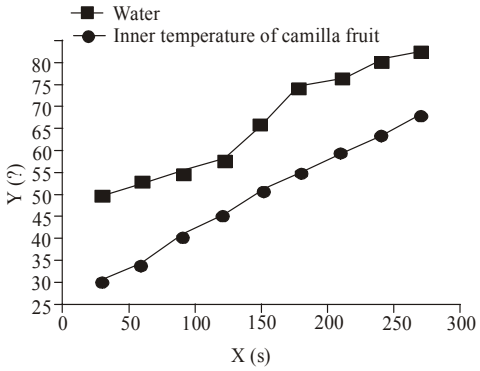

Fig. 1: Relation of camellia fruit heating time, temperature, crack length

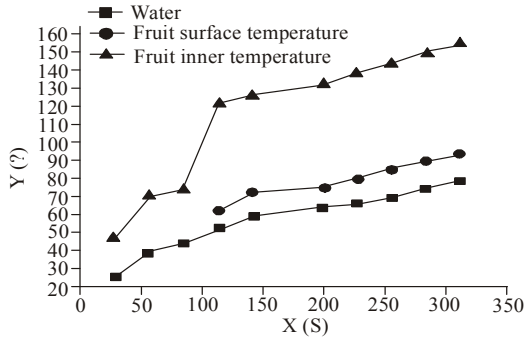

Fig. 2: Relation of another camellia fruit heating time, temperature, crack length

densities were observed, for example, density ranged from 0.00097112 to 0.0010005 g/mmP^{3}P. White blank paper tapes measured cracks' length aided by vernier caliper, cup poured in 450 mL water was involved in the microwave stove, the obtained datum were shown as Fig. 1.

Shielded thermocouples were used to determine inner temperature of camellia fruit, infrared induction hygronom was used to measure camellia fruit surface temperature, white blank paper tapes measured cracks' length aided by vernier caliper, cup poured in 400 mL water was involved in the microwave stove, the obtained datum were shown as Table 1. The crack type was near 120P^{0}P, drawn as "人".

The water beginning temperature was 20°C, beginning temperature of camellia fruit was 23°C, its' quality was 25.8 g. The fruit one diameter was 35 mm, one cross diameter was 40.5 mm, the other cross diameter was 32.1 mm. Relation of another camellia fruit heating time, temperature, crack length was shown as Fig. 2.

Observation of the crack forming process while microwave heating camellia oleifear: Two thousand and eleven (2011) fall's camellia oleifera fruit sizes,qualities,crack lengthes were shown as Table 2.

Sample No 1 cross diameter was 39.52 mm and 39.5 mm, the HlongitudinalH diameter was 39.92 mm, its' quality, related crack lengths were shown as Table 3. Relation of crack length of heated camellia fruit of No 1 and time was shown as Fig. 3.

Sample No2 cross diameter was 38.16 and 36.98 mm, the HlongitudinalH diameter was 38.04 mm, its' quality, related crack lengths were shown as Table 4. Relation of crack length of heated camellia fruit No 2 and time was shown as Fig. 4.

Table 1: Relation of another camellia fruit heating time, temperature, crack length

Time (sec)	Water temperature (°C)	Fruit inner temperature (°C)	Crack length (mm)	Crack type	Fruit surface temperature (°C)
30	26	47			
60	39	70			
90	44	73			
120	52	120			62
150	59	125			72
210	64	131	10.94		75
240	66	137	7.7/19.94		80
270	69	142	10.98/12.16/20.4	人	85
300	74	148	19.42/23.98/23.98	人	89
330	79	153	21.18/24.2/26.18	人	93

Table 2: Relation of camellia fruit sizes, qualities, crack lengths

					Heating time (30S)		Heating time (60S)	
No	Diameter 1 (mm)	Diameter 2 (mm)	Diameter 3 (mm)	Quality (g)	Crack length (mm)	Quality (g)	Crack length (mm)	Quality (g)
1	22.4	33.12	32.68	37.38		22.0	64.18	21.0
2	30.8	31.34	35.66	18.30		18.3	50.60	17.3

Table 3: Relation of No 1 camellia fruit qualities, crack lengths and types

Time (s)	Quality (g)	Crack length (mm)	Crack type
50	30.63	0	
60	29.57	4.78/5.2/5.28 = 15.26	
70	28.85	15.62/28.84/47.44 = 91.9	
80	27.97	24.3/34.62/47.5 = 106.42	
90	27.09	23.94/36.58/47.9 = 108.42	
100	26.32	23.94/37.34/47.56 = 108.84	
110	25.62	23.94/37.34/47.56 = 108.84	

Table 4: Relation of No 2 camellia fruit qualities, crack lengths and types

Time (s)	Quality (g)	Crack length (mm)	Crack type
50	27.46	0	
60	26.37	6.08/6.1/8.82 = 21	
70	25.14	8.4/14.42/17.26 = 40.08	
80	24.29	12.04/26.76/29.04 = 67.84	
90	23.54	14.98/31.72/35.9 = 82.6	

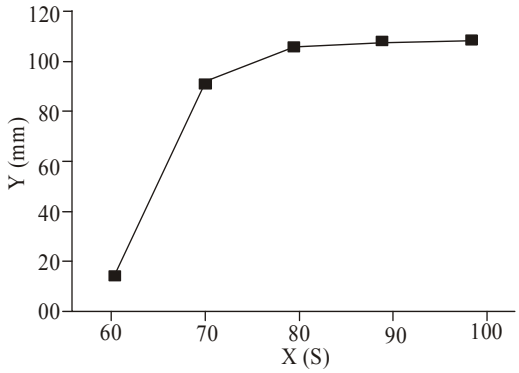

Fig. 3: Relation of crack length and time of heated camellia fruit of No 1

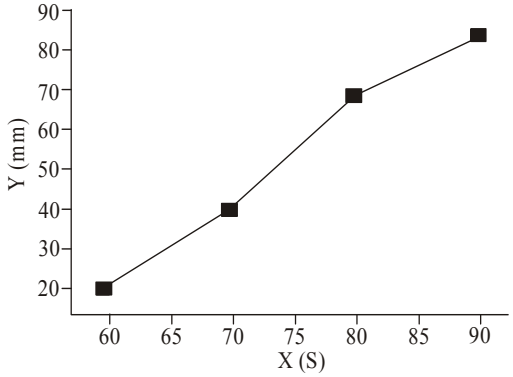

Fig. 4: Relation of crack length of heated camellia fruit No 2 and time

THEORY ANALYSIS

In the fact, the geometry shape of *Camellia oleifera* fruit can be described as formula (1):

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=1 \quad (1)$$

In the formula (1), Z axis is the direction where *Camellia oleifera* fruit suspends naturally.

According to the theory of fracture mechanics, under the action of stress, strain energy of per volume *Camellia oleifera* shell is shown as formula (2):

$$U^* = \frac{1}{V}\int f dx = \int \frac{f}{A}\frac{dx}{L} = \int \sigma d\varepsilon \quad (2)$$

The material of *Camellia oleifera* shell may as well be linear ($E = \sigma/\varepsilon$), thus the strain energy of per volume is shown as formula (3):

$$U^* = E\varepsilon^2/2 = \sigma^2/(2E) \quad (3)$$

While the inner crack of solid material increases to the length of a (Miyawaki, 1998), there will be the phenomenon of unloaded area near the free surface of the crack and the strain energy will be released. The simple method of energy releasing is shown as Fig. 5, that is, the triangle area, which is near the crack sides and the width is a, the height is βa, will unload completely and the material's other part will be under the action of whole stress σ. The choice of parameter β should be in line with Inglis solution and the loading situation causing surface stress, $\beta = \pi$. So the released whole strain energy U equals to the per volume's strain energy multiplying with the two triangle area volume, shown as formula (4):

$$U = -\frac{\sigma^2}{2E}.\pi\alpha^2 \quad (4)$$

It is the typical Ⅰ style crack for *Camellia oleifera* shell, so $\sigma = \frac{K_{Ic}}{\sqrt{\pi\alpha}}$, then:

$$U = -\frac{\sigma^2}{2E}.\pi\alpha^2 = -\frac{K_{Ic}^2}{2\pi Ea}.\pi\alpha^2 = -\frac{\alpha K_{Ic}^2}{2E} \quad (5)$$

In the heated process of *Camellia oleifera* fruit, power oringining from microwave is regarded as evenly affected to the heated object which the volume is V, the microwave stove volume is 21L, so the energy absorbed by *Camellia oleifera* fruit is as formula (6):

$$U' = \frac{800\ tV}{21}\ (\text{J}) \quad (6)$$

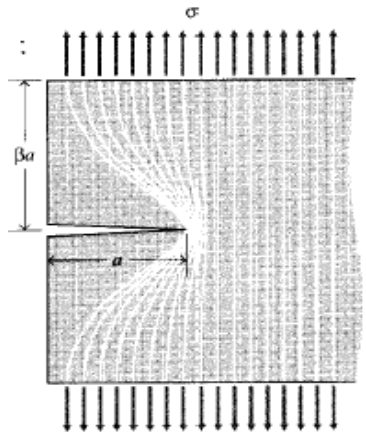

Fig. 5: Ideal unloading area near crack side graph

Table 5: *Camellia oleifera* seed size and crack length relation to different time

Direction diameter (dm)	Cross diameter 1 (dm)	Cross diameter 2 (dm)	Original quality (g)	Crack length after heated 60S (m)
0.3118	0.3746	0.3922	25.5000	0.07336
0.2240	0.3312	0.3268	37.3800	0.04418
0.3080	0.3134	0.3566	18.3000	0.0506
0.3188	0.3296	0.3706	21.4700	0.08454
0.3992	0.3952	0.3950	32.8800	0.01526
0.3804	0.3816	0.3698	0.3056	0.02100

The Table 5 shows the crack lengths heated by microwave after 60 sec relating to different *Camellia oleifera* fruit. According to the rule of energy conservation $U+U^{'}=0$ (Vander Wall SB, 2001):

$$\text{So } K_{\text{Ic}}^2 = 32000.\frac{V}{7\alpha}.E \tag{7}$$

As the ellipse sphere, the volume calculation as formula (8):

$$V=\frac{4\pi abc}{3} \tag{8}$$

Selected six group typical datum from Table 2 substituting to formula (7).

According to the six group parameters then calculating separately, V_1 = 0.02398557 dm^3, V_2 = 0.0126946 dm^3, V_3 = 0.0180231 dm^3, V_4 = 0.020379 dm^3, V_5 = 0.032612 dm^3, V_6 = 0.028092 dm^3, through calculating then the formula (9) is obtained:

$$K_{\text{Ic}}^2 = (1.1\sim9.8) * 10^3 E \tag{9}$$

E unit: N/m^2; K_{Ic} unit: $N.m^{-3/2}$

CONCLUSION

The results show that about 38% crack type is near-120º and the crack is produced almost at the time while it is heated about 60 sec. So the microwave heating method is rapid to separate the oil-tea camellia fruit and seeds.

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