Microwave thermal shocking assisted pistachios splitting mouth

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Abstract: The aim of this study was to evaluate the effect of microwave thermal shocking on cracking pistachio's mouth. A hundred closed nuts were soaked in water for 5 to 24 hours at different temperatures from 0ºC to 25ºC and then shocked thermally for creaking by microwave irradiation. Results showed that in 540W power and higher all 100 pistachios were split. The cracking started after 6 min and all 100 pistachios were split after 16 min microwave irradiation in 540, 720 and 900 W if the nuts were soaked for 5 hours in 25ºC water before.

Keywords: microwave thermal shocking, splitting mouth, pistachios

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1 Introduction

Pistachios have been well known as a delicious and healthful foodstuff in many countries worldwide. Pistachio nuts are cultivated in grape-like bunch and an external skin, called the hull, encases each nut. When mature the hull turns pinkish or reddish coloring and the inside shell splits, signifying the nut is ready to be harvested (Kouchakzadeh, 2011).

Pistachio shells crack open naturally once they ripen (smile pistachio), but sometimes the shell splits without breaking (Figure 1). These, also, are considered lower in quality or from trees that were not properly maintained and irrigated. In years past, pistachio products in central Iran have risen dramatically so that it is now about 380,000 hectares and produces annually 350,000 tons of pistachios where the pistachio export earnings are the largest among non-petroleum Iran's export industries (Kouchakzadeh, 2013). Over one third of crop yields were not split open spontaneously after ripening. The sorting of cracked nuts and those unopened was all done by hand, which can explain why pistachios were always more expensive than most other nuts.

Figure 1 Smile and closed pistachios

Often, unopened pistachios are cracked open by mechanical methods. First, unsplit pistachios were hammered by machine to make small cracks. This process takes 10-14 days working time for 25 tons of pistachios load. Then the pistachios were washed and steeped in water for about 5 hours in stainless steel silos. At this step, nuts have reached to the softest peel and could be cracked open by thermal shocking. Afterwards, the nuts were sent to dryers (Figure 2) where pistachios in bulk expose hot air at temperatures 90ºC to reach about 5% of moisture content. This needs three or four days for 25 tons of pistachios and consumes about 3500 Megajoules energy that is provided by gas torches and 40 kilowatts hour electricity (Hoseinzadeh, 2013).

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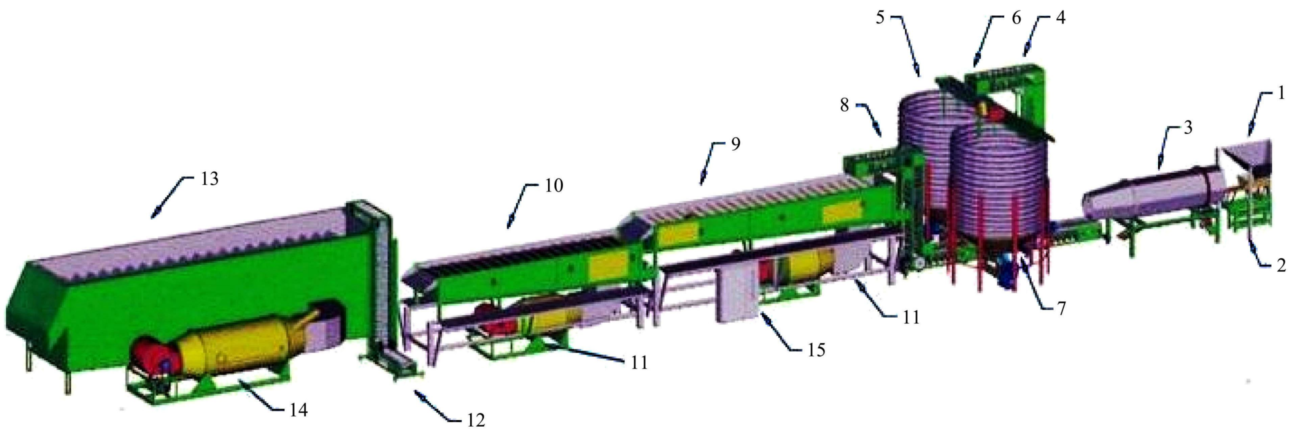

1. Hopper 2. Vibrator 3. Water system 4. "Z" shape elevator 5. Silo 6. Feeding vibrator 7. Discharge vibrator 8. "Z" shape elevator 9. Opener pistachio mouth 10. Cooler 11. Heater 12. "Z" shape elevator 13. Dryer 14. Heater 15. Electric cabinet

Figure 2 mechanically opened pistachio line (Momtazan Co)

Without the hammering process, the nuts should be steeped in cold water for 24 h and then were shocked thermally for creaking. The most difficulty of this method is the inability of fast cutting moisture content to about 5%, which can produce conditions in with Aflatoxin (fungal metabolites showing toxin) growth (Kouchakzadeh, 2013).

Thermal shock conditions are produced by rapidly moving the pistachios between two temperature extremes, and usually require that the transition time between the extremes is short, thereby creating a shock condition. Pistachios must remain at a temperature extreme before reaching equilibrium which can vary in a few minutes, depending on the method of producing the temperature extremes, the capacity for heat transmission, and the mass of the pistachios. The most used methodologies for producing thermal shock environments are hot-air thermal shock systems using separate chambers and a mechanism to move the pistachios between the chambers. Although these chambers are readily available, they are slowly to operate and provide a low heat exchange rate to the pistachios.

In a conventional drying, heat transfer is predominantly by conduction and convection to the surface shell of the nuts followed by conduction from the shell to the kernel centre. During heating the high radiant loading is required to do the task in a fixed period resulting in the temperature gradient across the nuts. Because the thermal conductivity of pistachios is low (at the range of 0.231 to 0.466 W/m°K) (Kouchakzadeh and Tavakoli, 2009), there is a tendency for the temperature gradient to result in a large thermal mismatch between the kernel and the shell. This leads to a stress at the shell of the pistachios nuts. The described thermal mismatch generates compressive thermal stresses at the shell and as a result, the propagation of cracks is inhibited. But, if the thermal gradient is enough large, cracking will occur. It has been found that this maximum temperature gradient varies with the pistachios and temperature making it difficult to predict and requiring extensive trials to determine the best firing schedule for pistachios.

By lowering or eliminating features such as hammering process that are costly and delaying to produce, the pistachios openings process will be able at higher yields, lower costs, improved quality and with low risk of Aflatoxin growth.

In this context, capability suggests the potentials of microwave thermal shock cracking of pistachios nuts and is quantified by metrics. Microwave accelerated thermal shock method was developed to emulate traditional hot-air methods, while significantly reducing the defects of traditional methods. The microwave irradiation provides rapid thermal transfer to the pistachios, and reduces the time for the pistachios to reach temperature equilibrium. The uses of microwave to generate heat in foodstuff were fully known. The most widely commercially used frequency is 2.450 GHz. The electromagnetic energy upsets the hydrogen bonds associated with the dipole rotation of polar molecules. With the ionic interactions, the electric field causes the migration of ions. These mechanisms produce friction among molecules, as polar molecules straighten in the electromagnetic field and as ions move in the electric field (Wang et al., 2003). When the waves can penetrate directly into the material, heating is volumetric (from inside out) and provides fast and uniform heating throughout the product. This creates an outward flux of rapidly escaping vapor. Because the waves can penetrate directly into the material, heating is volumetric (from inside out) and provides fast and uniform heating throughout the product. The quick absorption of energy by water molecules causes rapid evaporation of water; this creates an outward flux of rapidly escaping vapor (Schiffmann, 1992). Steam will build up inside the sealed nut, causing them to detonate like popcorn.

Researches of microwave heating are found for many heat treatment operations in the food processing. Some of these recent uses include drying of soybeans (Gowen et al., 2008), tempering of frozen potato puree (Seyhun et al., 2009), minimal processing of apple puree (Picouet et al., 2009), drying of garlic cloves (Figiel 2009), processing of cream of asparagus (Giuliani et al., 2010), roasting of hazelnuts (Basaran and Akhan 2010), and drying of pistachios (Kouchakzadeh and Shafeei 2010), dehydration of coriander leaves (Sarimeseli, 2011), mushrooms (Lombraña et al., 2010), sea cucumbers (Duan et al., 2010) are some usage of microwave in for food processing.

The effect of microwave thermal shocking for cracking pistachios shell has not yet been tried. The purpose of the present work is to study the effect of microwave heating on pistachios splitting process.

2 Materials and methods

Pistachio samples of major variety: Akbari, were used in this study. For a specific test, pistachios are rejected if they are significantly larger or smaller than the subjective average size. The length distribution of pistachio nuts in 1.60 to 1.70 cm was used for the experimental runs. The unsplit pistachios graded by experts were got from pistachio processing plant Qom province, Iran during harvesting season in September 2012. The samples were taken after dehulling process; for each test, 100 pistachios were chosen, put in plastic bags, and placed in a refrigerator before conducting experiments. The moisture contents of samples were determined by oven drying at temperature of 130ºC for 6 h according to a standard method (ASABE, 2005).

The pistachios samples were steeped in water and kept in cooled incubator (Model IPP 400, Memmert, Germany) for 5, 10, 15, 20 and 24 h at temperatures 0ºC, 5ºC, 10ºC, 15ºC, 20ºC and 25ºC. Then a monolayer of 100 soaked pistachios was placed on plate of microwave oven (NN-SD762S, Panasonic, China) to perform thermal shocking. The samples were heated up rapidly in the microwave chamber in five power levels at 900, 720, 540, 360 and 180 W. After every 2 min, the microwave was stopped and counted the split shell pistachios. All experiments were done in triplicate.

3 Results and discussion

The initial moisture of pistachios was 58.3% (d.b.). Table 1 presents the moisture content after various soaking time and temperature. The differentiations of water-sucking are shown in Figure 3.

Table 1 Moisture content of pistachios after socking (%, d.b.)

Temperature /ºC	Time/h					
	0	5	10	15	20	24
0	58.3	86.1	96.5	102.3	106.0	108.1
5	58.3	86.4	97.8	104.9	107.4	108.9
10	58.3	87.9	99.6	107.8	108.6	109.3
15	58.3	88.1	102.8	110.3	111.6	112.6
20	58.3	89.6	107.3	111.9	113.8	115.3
25	58.3	90.2	108.6	112.3	114.7	116.1

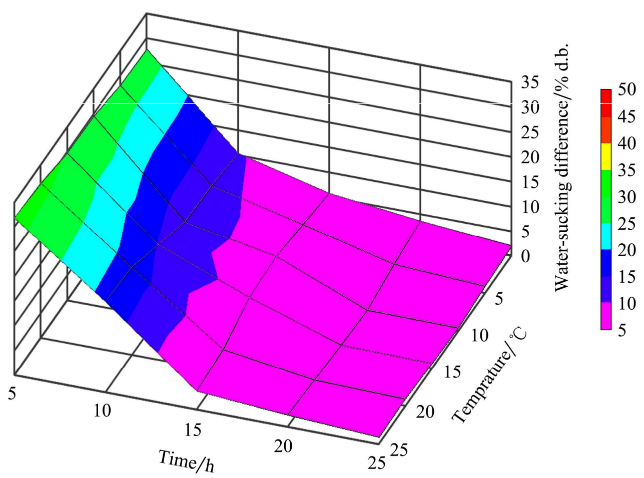

Figure 3 Differentiations of water-sucking of unsplit pistachios

As can be observed in Figure 3, the water temperature appears to be not very effective. At initial hours, the absorption of water by pistachios nut caused high sucking rate, considering the differentiation values at 10, 15, 20 and 24 h, when the most of nut's porosity is filled the values is reduced.

Table 2 shows the summarized results of the nuts splitting after 20 min shocking time. As shown in Table 2, in 540 W and higher all 100 pistachios have been split. Figure 4 illustrates the effect of microwave shocking time on splitting nuts after 5 h soaking in 25℃ water. In 540, 720 and 900 W microwave powers the cracking started after 6 min and all 100 pistachios were split after 16 min irradiation.

Table 2 Number of split nuts after 20 min shocking (*mean*±*STD*, *N*=3)

Soaking temperature /℃	Soaking time/h	Power/W				
		180	360	540	720	900
0	5	82±3	89±2	100±1	100±0	100±0
	10	78±2	86±5	100±0	100±0	100±0
	15	73±2	85±4	100±1	100±0	100±0
	20	72±4	83±3	100±0	100±0	100±0
	24	69±1	81±2	100±0	100±0	100±0
5	5	80±0	88±4	100±2	100±0	100±0
	10	79±4	86±1	100±0	100±0	100±0
	15	76±3	85±2	100±0	100±0	100±0
	20	73±2	82±3	100±0	100±0	100±0
	24	70±3	80±4	100±0	100±0	100±0
10	5	77±4	89±2	100±1	100±0	100±0
	10	77±2	84±1	100±1	100±0	100±0
	15	72±2	81±5	100±1	100±0	100±0
	20	70±1	83±3	100±2	100±0	100±0
	24	64±1	72±4	100±0	100±0	100±0
15	5	75±0	86±2	100±0	100±0	100±0
	10	71±4	83±1	100±0	100±0	100±0
	15	70±2	83±0	100±0	100±0	100±0
	20	63±3	75±2	100±1	100±0	100±0
	24	59±4	74±3	100±0	100±0	100±0
20	5	82±5	93±2	100±0	100±0	100±0
	10	79±4	88±2	100±2	100±0	100±0
	15	72±3	86±1	100±1	100±0	100±0
	20	70±3	88±5	100±1	100±0	100±0
	24	69±4	84±4	100±0	100±0	100±0
25	5	76±2	82±3	100±0	100±0	100±0
	10	76±4	83±4	100±1	100±0	100±0
	15	75±5	84±2	100±1	100±0	100±0
	20	70±4	88±1	100±0	100±0	100±0
	24	64±4	84±2	100±0	100±0	100±0

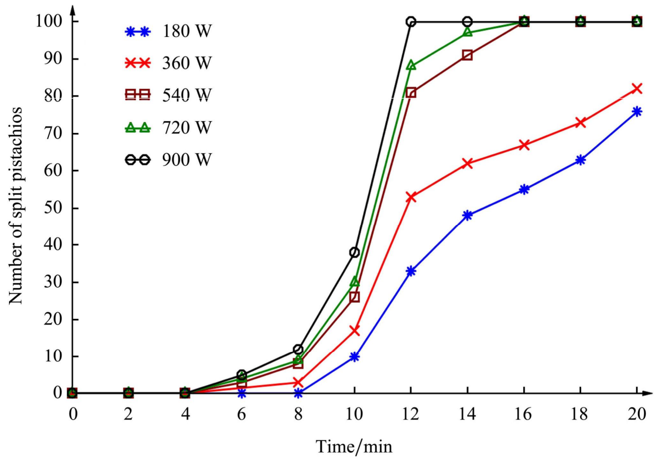

Figure 1 Split pistachios vs. time at various microwave power

4 Conclusions

In this study, it has been showed that the proposed microwave thermal shocking are effective in splitting of pistachios nuts. Different soaked period were formed and the microwave shocking method offered the best splitting of 100%. Future applications of microwave thermal shocking to opening pistachios' mouth will include microwave-convective system to drying process of pistachios and that will be suitable for practicable implementation.

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