Experimental Investigation on Magnetic Field Assisted Freezing

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Outline

1. Background
2. Materials and methods
3. Results and discussion
4. Other relevant experimental results
5. Conclusion

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Background

Cherry is very popular among the consumers all around the world

- The cherry has great taste
- The cherry has various effectiveness
- The cherry is good for health

- The shelf life is fairly short
- The cherry is perishable
- The cherry is not easy to store

New method is needed eagerly

Background

Some innovative assisted freezing methods spring up in recent years.

- Microwave assisted freezing
- High pressure assisted freezing
- Electric field assisted freezing
- Magnetic field assisted freezing

The researches on the magnetic field assisted freezing have some controversy

Background

The controversy of the magnetic field assisted freezing

The further researches are needed to verify the effect on foods

Time	Author	Object	Method	Result
2012	Wowk	-----	Many investigations are analyzed to explore the magnetic influence	The effect of the magnetic is queried from many aspects
2015	Choi et al.	beef	Compared the Ultrastructure changes and Sensory Characteristics under the electromagnetic and air blast freezing	The ice crystals are smaller and the food quality is better under the electromagnetic freezing
2015	Mok et al.	saline solution	The saline solution is frozen under the pulsed electric and static magnetic field	The ice crystal distribution is best when the electric and magnetic field combined
2017	Zhao et al.	liquids	Deionized water, sodium chloride etc. are frozen under the static magnetic field	The effects on the nucleation time and temperature are different when the magnetic field is applied to different liquids
2017	Mok et al.	chicken breasts	The chicken breasts are frozen under the pulsed electric and oscillating magnetic field	The super cooling degree is increased and the food quality is better under the combination of the electric and magnetic field
2017	Otero et al.	crab sticks	The crab sticks are frozen under the weak oscillating magnetic fields	Compared with the air blast freezing, it has no advantages
2017	Fernández-Martín et al.	Egg white and yolk	The egg white and yolk are frozen in the CAS	The treatment of the magnetic field has no advantages
2018	Otero et al.	pure water, sodium chloride	The effect of the static magnetic fields on supercooling and freezing kinetics are investigated	The static magnetic field has no influence on the freezing time and super cooling degree

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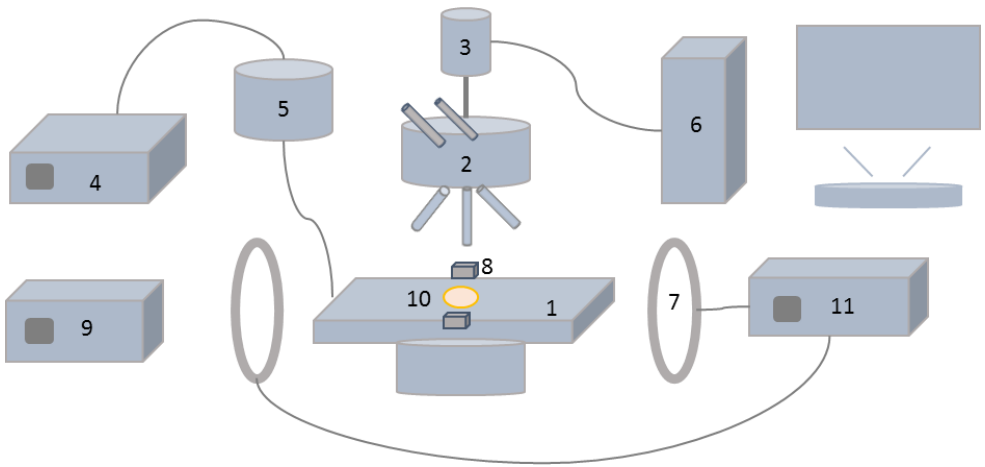
Materials and methods

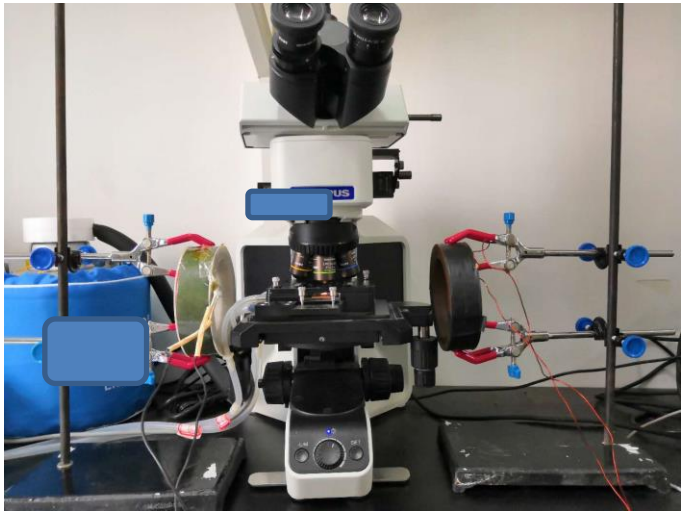
Sample preparation

- The fresh cherry samples are purchased from a fruit supermarket
- They are preserved under the environment temperature of 25℃
- The similar size and shape cherries are chosen to cut into small slices (10mm×3mm×0.1mm)

Materials and methods

Experiment device





1cooling stage 2 optical microscope 3 CCD camera 4 controller
5 nitrogen tank 6 computer 7 alternating current coil
8 permanent magnet 9 Gauss meter 10 section sample

- The cooling capacity of the cooling stage is provided by the nitrogen tank, and the cooling rate and the target temperature are set by the controller
- The optical microscope fitted with a CCD camera to transfer the real-time image to the computer

Materials and methods

PMF treatments

Permanent magnet

- The magnetic field intensity of one piece permanent magnet is about 1.5 mT
- The magnetic field intensity can be adjusted by increasing or reducing the number of permanent magnet
- The magnetic field intensities in the cooling stage center range from 0.0 mT to 15.0 mT at intervals of 1.5 mT

Materials and methods

AMF treatments

Alternating current coil

- The alternating magnetic field is generated by the alternating current coil that is energized
- When the values of the current are varied from 0.00 A to 2.50 A at intervals of 0.25 A, the corresponding peak values of the magnetic intensity in the cooling stage center are 0.00, 0.21, 0.46, 1.29, 2.81, 5.40, 6.43, 7.64, 12.63, 16.04, and 17.44 Gs respectively

Materials and methods

Testing process

- The cherry slice is placed on the glass slide at the center of the cooling stage
- The cooling rate and the target temperature are set as 4℃/min and -30℃ respectively
- The PMF which ranges from 0.0 to 15.0 mT and AMF which ranges from 0.00 to 17.44 Gs are applied to the cherry slice during the freezing process, respectively
- Each trial of different condition is repeated four times to reduce the error

Materials and methods

Evaluation index

- The cooling stage temperature when the phase change process occurs is recorded to represent the degree of supercooling
- The changes of the cell structure are described by the microscopic images
- The ice crystal area is calculated under each experiment condition to represent the food quality

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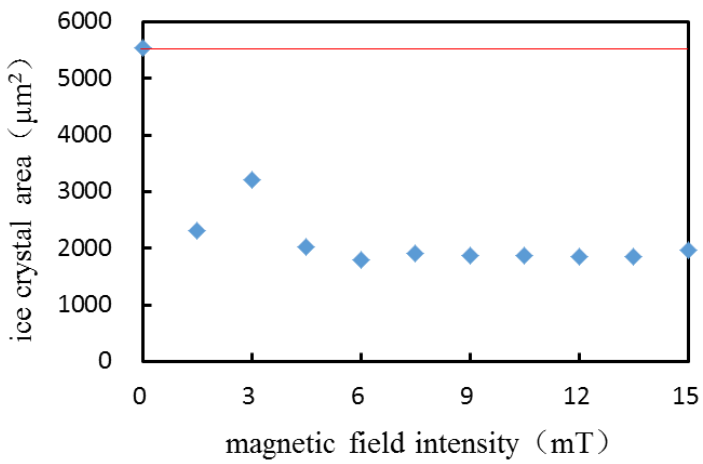
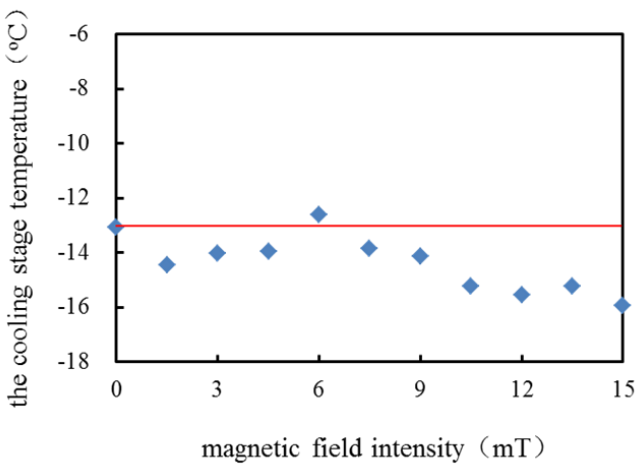
Results and discussion

PMF treatments

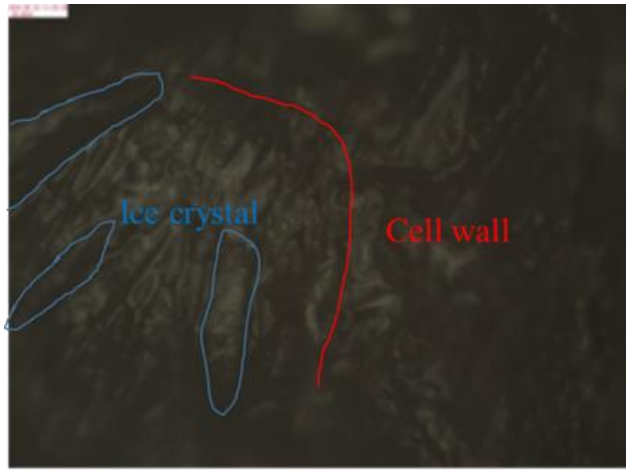




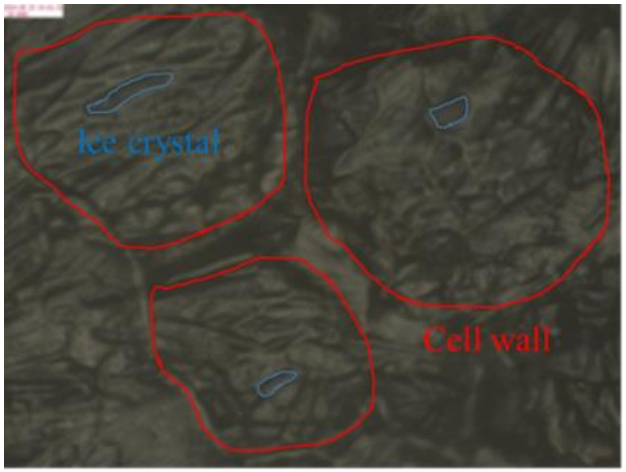
- It is clear that the ice crystal area is reduced when the magnetic field is applied.
- Also, the cooling stage temperature is decreased at the same time. But there is no obvious rule.

Results and discussion

PMF treatments



Control group

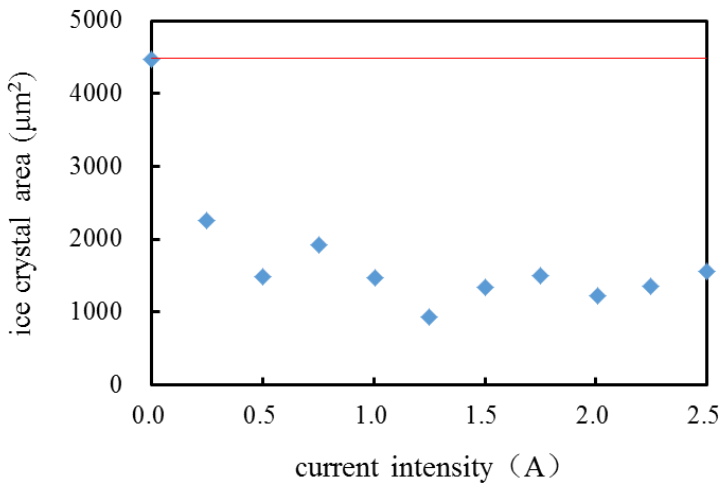


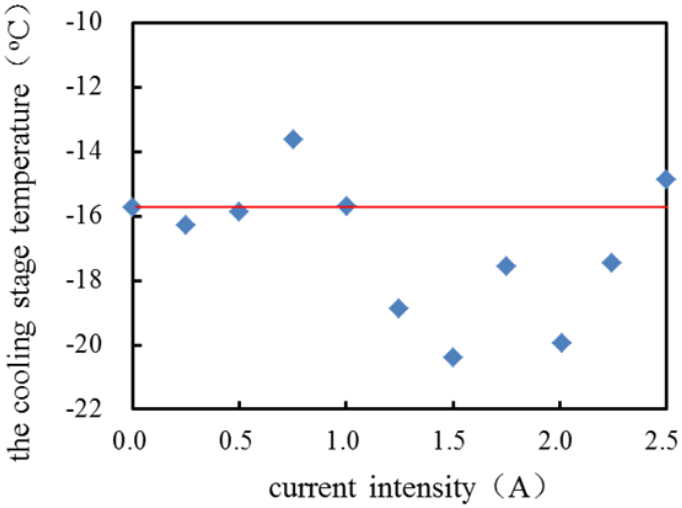
With magnetic field

The cellular structure remains well when the magnetic field is applied. The ice crystal intracellular and extracellular is homogeneous. The ice crystal area is relatively small.

Results and discussion

AMF treatments

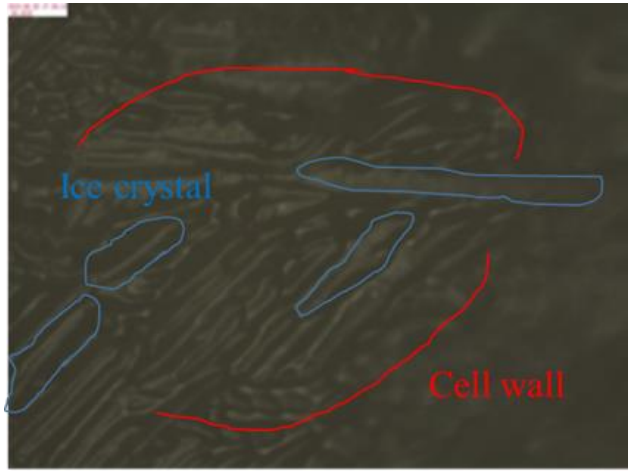




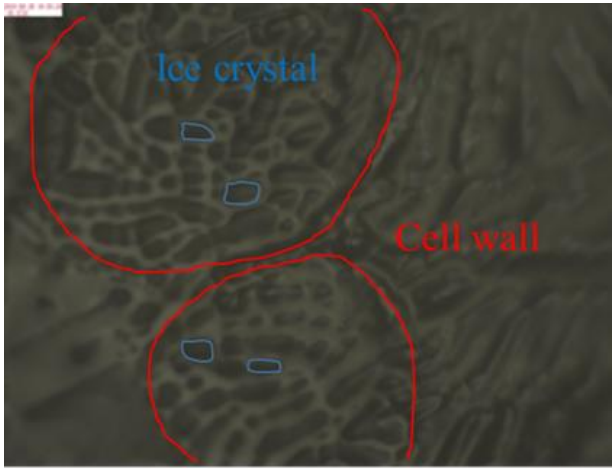
- The ice crystal area is reduced when the magnetic field is applied.
- Also the cooling stage temperature is decreased at the same time. But cooling stage temperature is fluctuated.

Results and discussion

AMF treatments



Control group



With magnetic field

The cellular structure remains well when the magnetic field is applied. The ice crystal intracellular and extracellular is homogeneous. The ice crystal area is very small when the alternating magnetic field is applied.

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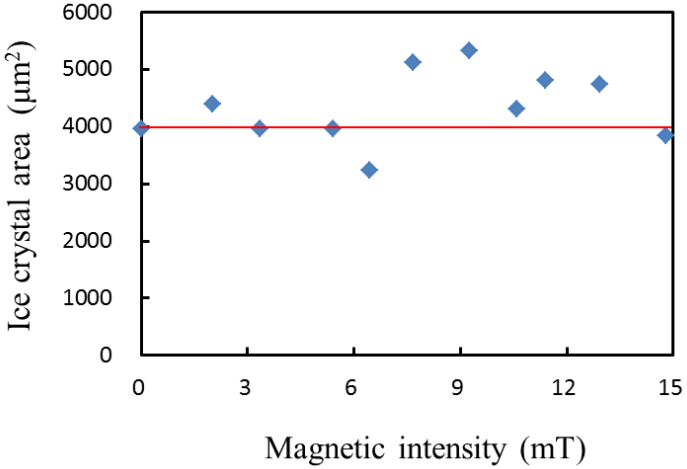
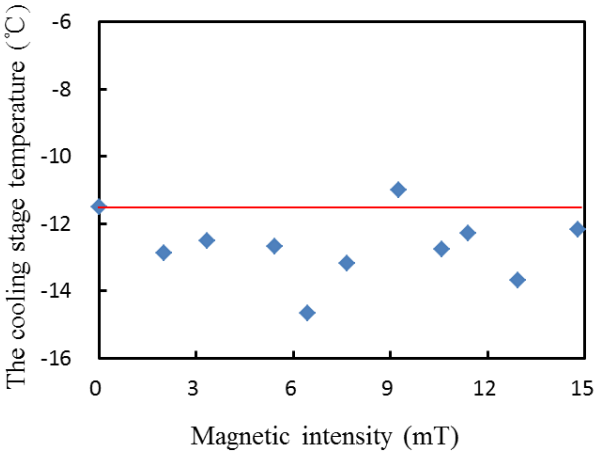
Other relevant experiment results

PMF treatments

Blueberry



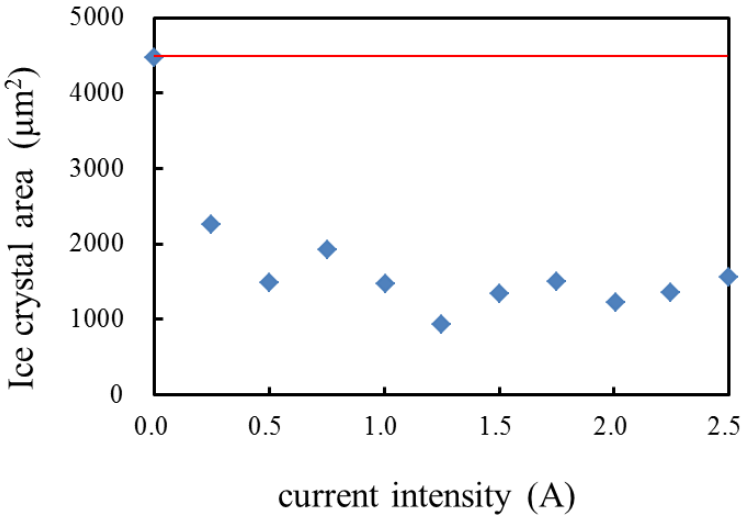


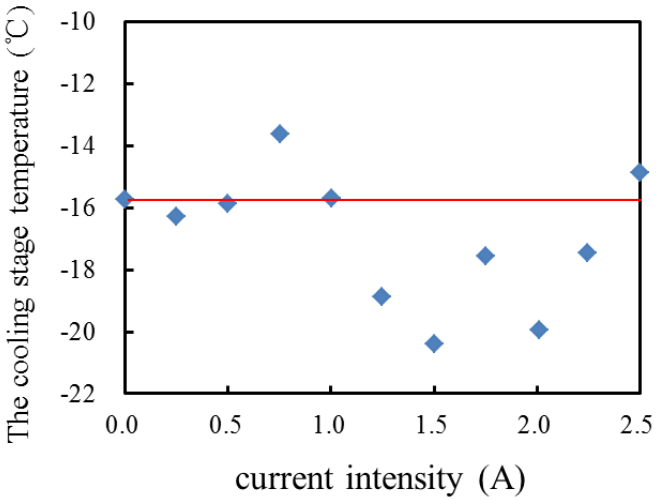
The permanent magnetic can reduce the cooling stage temperature when the phase change occurs, but has little influence on the ice crystal area.

Other relevant experiment results

AMF treatments

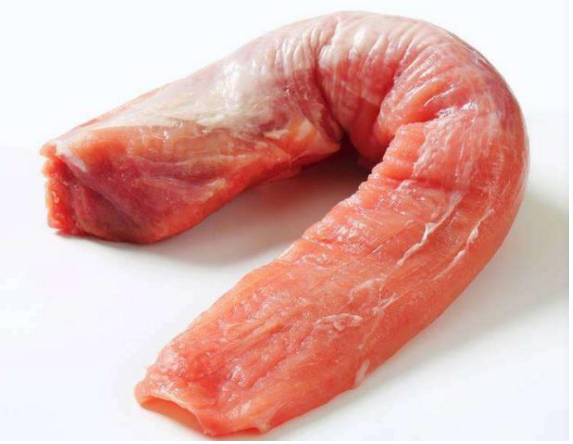
Blueberry



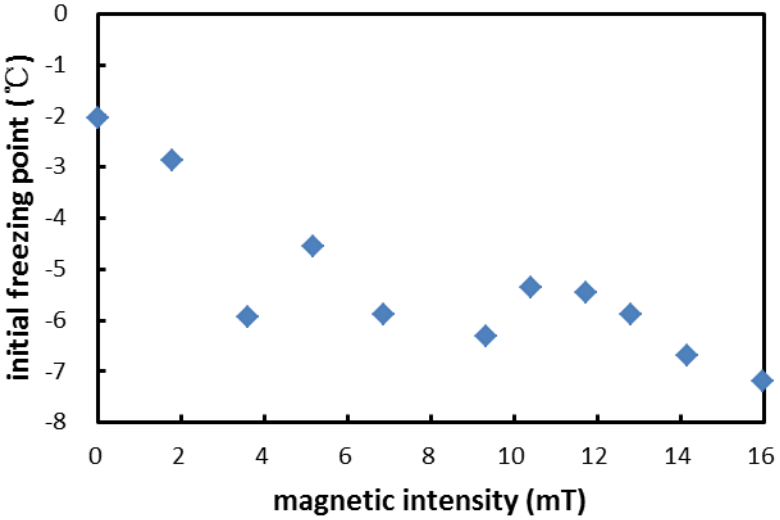


The alternating magnetic can reduce the cooling stage temperature when the phase change occurs, and the ice crystal area can be reduced drastically.

Other relevant experiment results



Pork tenderloin



When the permanent magnetic field is applied on the pork tenderloin, the initial freezing point is decreased with the increase of magnetic intensity. The most difference between the experiment group and the control group reaches to 5.14℃. The lower initial freezing point can lead to smaller ice crystal, so the magnetic field can improve the food quality.

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Conclusion

- The permanent magnetic field and the alternating magnetic field have some positive effect on the foods during the freezing process, ,but the alternating magnetic field has a better effect than the permanent magnetic field.
- When the PMF and AMF are applied on the cherry section sample, the cooling stage temperature is lower than the control group, the cellular structure remains better especially the AMF assisted freezing, the average ice crystal area are reduced about 50% and 70% when the PMF and AMF are applied respectively.
- Although the PMF and AMF assisted freezing have positive effect on the food quality, the variation tendency with the intensity of the magnetic field is not very obvious.

Conclusion

- As for different foods, the effects of the magnetic field on the food quality are different, it may be attributed to the mechanism of different magnetic fields and different food composition.
- The main problem is that there is no obvious rule. The temperature measuring technology on the food slices is not mature. The relevant mechanism on the magnetic filed assisted freezing is not clear up to now. Thus, the more careful work should be done on the magnetic field assisted freezing in the future.

QUESTION AND ANSWER

Thanks for your attention!

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