

# Cryogenic freezing vs. conventional freezing: A comparative study on texture and nutrient retention in meat products.

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## Introduction

Freezing is a crucial method for preserving meat products, extending their shelf life while maintaining safety and quality. Two predominant freezing techniques are conventional freezing and cryogenic freezing. Conventional freezing utilizes mechanical refrigeration systems, whereas cryogenic freezing involves the use of extremely low-temperature gases such as liquid nitrogen or carbon dioxide. This study examines the differences between these methods in terms of texture and nutrient retention in meat products [1].

Conventional freezing involves cooling meat gradually using air blast freezers, plate freezers, or tunnel freezers, which operate at temperatures ranging from  $-18^{\circ}\text{C}$  to  $-40^{\circ}\text{C}$ . The freezing rate is relatively slow, leading to the formation of large ice crystals within the muscle fibers of the meat.

Cryogenic freezing, in contrast, employs liquefied gases such as nitrogen ( $-196^{\circ}\text{C}$ ) or carbon dioxide ( $-78.5^{\circ}\text{C}$ ). The meat is exposed to these gases, leading to an ultra-rapid cooling process, which minimizes the size of ice crystals formed during freezing. One of the primary concerns in frozen meat is texture degradation due to ice crystal formation. Conventional freezing results in larger ice crystals, which can rupture muscle fibers and cell walls. Upon thawing, this can cause increased drip loss, leading to a drier and less tender texture [2].

Cryogenic freezing, on the other hand, forms much smaller ice crystals due to its rapid freezing rate. This minimizes cellular damage, preserving the meat's structural integrity and resulting in better texture retention after thawing. Studies show that cryogenically frozen meat is often more tender and retains its juiciness compared to conventionally frozen meat [3].

Freezing affects the retention of essential nutrients such as proteins, vitamins, and minerals. Conventional freezing can lead to moderate nutrient degradation due to slow freezing and oxidative processes occurring during prolonged storage. Vitamin C and B vitamins, which are highly sensitive to temperature fluctuations, may degrade over time.

Cryogenic freezing preserves nutrients more effectively because of its rapid freezing action, reducing the exposure of meat to oxidation and enzymatic reactions. Studies have indicated that cryogenic freezing retains higher levels of vitamins, amino acids, and overall protein integrity compared to conventional freezing [4].

Drip loss, or the amount of liquid lost from meat upon thawing, is an important quality indicator. Conventional freezing results in higher drip loss due to the extensive damage caused by large ice crystals. The lost fluid often contains essential proteins and minerals, negatively affecting both the

nutritional value and sensory properties of the meat.

Cryogenic freezing significantly reduces drip loss since the rapid freezing process prevents excessive cellular damage. This results in higher moisture retention, leading to improved juiciness and flavor [5].

## Conclusion

Both freezing methods offer benefits, but cryogenic freezing outperforms conventional freezing in preserving texture, moisture, and nutrients in meat products. Although cryogenic freezing is costlier due to high operational expenses and the need for specialized equipment, it provides superior quality retention, making it an ideal choice for premium meat products. For large-scale, cost-effective operations, conventional freezing remains a viable option despite its drawbacks. Future advancements in freezing technologies may bridge the quality gap while improving economic feasibility.

## References

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