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Product load in potato cold storage: A review

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Abstract
In a commercial potato cold storage, the load product is a major component in a refrigeration system, particularly during the initial cooling period following the introduction of freshly harvested tubers. The magnitude and variation of load depend on the quantity of stored potatoes, initial temperature, specific heat, loading pattern, rate of loading, cooling duration, heat generated through respiration etc. The irregular loading patterns can be produced substantial fluctuations in refrigeration demand and affecting compressor operation, electrical energy consumption and quality of stored potatoes. This review study shows the characteristics of product-load, also the relationships among product load and energy consumption.

Keywords: Potato cold storage, Product load, Product cooling load, Refrigeration capacity

1. Introduction

Potato (*Solanum tuberosum* L.) is an important semi-perishable commercial crop that is require appropriate post-harvest handling and storage to maintain its quality and market value. In cold storage, beyond the harvesting season, potatoes to be preserved over extended periods and supports the availability of produce (ur Rehman *et al.*, 2026)[14]. According to, Zhen *et al.* (2025)[15], the potato preservation under the desirable storage conditions demands significant energy, mainly to meet refrigeration requirements and maintain the required storage temperature and relative humidity (RH).

The energy requirement depends not only on the characteristics of the storage construction and design parameters (like evaporator, condenser, compressor, refrigerant pipelines and pressure-vessels) but also on stored quantity and temperature of the product introduced into the storage chamber. Sáenz-Baños *et al.* (2022)[12] emphasizes the importance of control entering temperature of product, improving refrigeration performance and reducing unwanted heat gain.

The total refrigeration load consists of combine effect of various components, like transmission load through walls, floor and roof; product load; infiltration load; due to human load and equipment related heat gain of a commercial cold storage (Khatun *et al.*, 2026)[10]. Among these components, the product load represents the heat that must be removed from incoming potatoes to achieve the desired storage temperature, together with the heat subsequently generated by the potatoes during storage (Chourasia *et al.*, 2004)[3]. The distinction between these two contributions is important because their magnitude and temporal distribution differ considerably. They also suggest that product cooling usually creates a substantial demand during initial loading, whereas respiratory heat continues to contribute to the refrigeration requirement during storage.

The product loading process into the cold storage chamber may extend over several days or weeks (Thompson, 2004)[13]. During this period, newly introduced potatoes may coexist with previously loaded potatoes that are already undergoing cooling. Consequently, the instantaneous refrigeration demand varies according to the quantity of warm potatoes entering the storage chamber and the remaining cooling requirement of the stored product. In a refrigeration system design based on a predetermined loading schedule, may not accurately reflect the variations in cooling requirements associated with actual potato loading practices. Chourasia *et al.* (2008)[5] investigated product-cooling loads under the different loading patterns and cooling rates and demonstrated the importance of considering their time-dependent behaviour. Their work provides a useful understanding why product load should be evaluated dynamically rather than as a single fixed value.

The present review focuses an overview of the effects of the contribution of product load on refrigeration demand in potato cold storage systems. It examines the effects of quantity of potatoes, initial product temperature and cooling duration on refrigeration requirements and energy use. Furthermore, the review identifies existing knowledge gaps and future research priorities for optimizing refrigeration system performance, improving energy efficiency, maintaining potato quality, etc. under the practical operating conditions. In addition, the review identifies existing research gaps and potential future investigations for optimizing refrigeration system performance, improve energy-efficiency and minimize deterioration of product quality during storage period.

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2. Review of literature

2.1. Refrigeration demand based on product load

In potato cold storage, the product load defines three major components like sensible cooling load, metabolic heat of respiration and the latent heat associated with moisture loss (Chourasia *et al.*, 2004)[3]. The sensible cooling load represents the heat that must be removed to reduce the temperature of freshly loaded potatoes from their initial temperature to the desired storage temperature. Chourasia *et al.* (1999)[6] define that the metabolic heat of respiration refers to the heat released by potatoes during respiration throughout the storage period, which contributes to the continuous refrigeration requirement. In addition, moisture loss occurs through evaporation from the potato surface, result as weight loss and potential deterioration of product quality (Chourasia *et al.*, 2005)[7].

Therefore, accurate evaluation of these components is essential for estimate the total refrigeration load based on the actual product load and maintain potato quality and also, determine the required refrigeration capacity. On a particular day (t), Khatun *et al.*, (2026)[10] estimate the product load (Q_p in kW) and the equation is –

$$Q_{p,t} = m_p[\left(\frac{c_p\,\Delta T_{p,t}}{86400} + q_{res,t} - \frac{m_{l,t}\left(h_{eva,t}\right)}{86400}\right)] \quad (1)$$

where, m_p is mass of the product loaded (in kg), c_p is specific heat of product (in kJ kg^{-1} °C^{-1}), $q_{res,t}$ is metabolic heat of respiration (in kW) and m_l is rate of moisture loss from the product (in kg day^{-1}).

2.2. Impact of the product quantity on cooling load

According to Czerko *et al.* (2023)[8], the stored potato directly influences the amount of sensible heat that must be removed. For the same initial temperature, final temperature and specific heat, doubling the potato mass approximately doubles the total sensible cooling energy. However, the average refrigeration capacity required depends additionally on the time allowed for cooling and the actual loading pattern. For a commercial potato cold storage, National Horticulture Board (Anonymous, 2010)[1], provides technical guidelines to estimate the peak refrigeration load to consider the importance of product properties, including specific heat capacity and heat generated through respiration.

The initial temperature of product is an important key factor that influences the required refrigeration energy for product cooling. When potatoes enter the storage chamber at higher temperature, have a larger temperature gradient between the incoming product and the storage environment and it increases the sensible heat load. Sáenz-Baños *et al.* (2022)[12] identified control of product entry temperature as one of the measures relevant to reducing energy demand. Their study emphasizes that the initial temperature of potatoes should be evaluate the refrigeration load under the actual operating conditions rather than a predetermined constant in the design process.

2.3. Effect of loading rate and loading density

Loading rate describes the quantity of stored potatoes into the chamber per unit time. Chourasia *et al.* (2008)[5] examined the combinations of three cooling rates and five loading patterns and found that the loading rate influenced refrigeration demand. They also identified a combination involving a 30 day of cool-down period and a linearly decreasing loading rate that reduced the refrigeration demand while allowing an increase in moisture loss. These findings indicate that the refrigeration demand of a commercial potato cold storage is closely related to operational scheduling.

Loading density is another important parameter which is affecting the cooling of product temperature during storage time. According to, Chourasia *et al.* (2007)[4], it can be expressed as the mass of stored potatoes per unit volume of the chamber or per unit volume occupied by the potato stack. However, the arrangement of potato bags plays an important role in maintaining uniform air circulation within the storage chamber. When stacking restricts the airflow, it can reduce heat transfer from stored potatoes located in the central regions of the stacks and resulting in the variations of temperature that cannot be adequately identified through air temperature measurements taken at a limited number of locations.

Chourasia *et al.* (2004)[3] evaluated loading density, cooling duration and power consumption in a commercial potato cold storage. Their investigation has shown the cooling performance and storage losses associated with several interacting operational and design parameters. These findings indicate that loading density should not be optimized solely to maximize the mass of stored potatoes per unit chamber volume. An appropriate balance between storage capacity, airflow distribution, cooling uniformity and refrigeration energy demand is also required.

2.4. Influence of cooling rate and cooling duration

The cooling rate is an important factor which direct influence on the refrigeration demand during the initial cooling period. Increasing the cooling rate requires a higher instantaneous heat-removal capacity, while a comparatively longer cooling period allows the refrigeration load to be distributed over time. Therefore, the selection of a suitable cooling rate has implications for both refrigeration-system operation and energy consumption.

Chourasia *et al.* (2008)[5] highlighted the importance of balancing cooling rate with refrigeration capacity and moisture retention in stored potatoes. Their findings suggest that the fastest possible cooling is not always desirable for long-term commercial storage and that cooling conditions should be selected to maintain product quality and refrigeration efficiency.

Thus, an appropriate cooling schedule should consider initial temperature of product, refrigeration capacity, airflow, moisture loss and storage quality. Furthermore, in commercial prevailing condition, monitoring product temperature at representative positions within the stacks provides a more reliable assessment of cooling performance than relying exclusively on chamber-air temperature.

2.5. Effect of product load on energy consumption

Product load influences the electrical energy consumption by determining the refrigeration capacity required to remove heat from the incoming potatoes (Eltawil, 2007)[9]. An increase in product load generally increases the cooling demand, potentially requiring the refrigeration system to operate for extended periods or at a higher capacity. However, the corresponding electrical energy consumption depends not only on the quantity and thermal condition of the potatoes but also on the overall performance of the refrigeration system including compressor capacity, evaporating and condensing temperatures, operation of evaporator design and the energy requirements of auxiliary equipment.

Sáenz-Baños *et al.* (2022)[12] reported that refrigeration accounted for approximately 60 – 70% of electricity consumption. They also demonstrated that a combination of energy-efficiency including refrigeration improvements, insulation, infiltration control and management of product entry temperature, reduced the standardized energy demand by 16.41% relative to previous years.

3. Summary of key literature

The literature consistently indicates that product load is a dynamic component of the refrigeration demand. Its magnitude is governed not only by the mass of stored potatoes but also by the initial temperature of product, the rate and sequence of loading, the required cooling time and heat generated during storage.

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4. Research gaps and future scope

Although previous studies have established the importance of product-cooling load in potato cold storage and several aspects require further investigation. Future studies should develop time-dependent models to estimate the product-cooling load under the actual loading and operating conditions. Such models should incorporate daily loading quantities, incoming potato and storage-air temperature and, also the temperature change of stored potatoes during cooling period. This would help determine the peak refrigeration demand more accurately than the evaluation based on uniform loading assumptions.

Reference	Focus	Relevance to product load
NHB (2010)[1]	Potato cold-storage design and estimation of refrigeration load	Provides design assumptions as well as specific heat, respiration and product cooling for potato.
Chourasia *et al.* (2004)[3]	Performance of commercial storage	Shown loading patterns, cooling rates and power consumption.
Chourasia and Goswami (2008)[5]	Loading patterns and cooling load of product	Illustrates the interaction between loading time and cooling capacity.
Sáenz-Baños *et al.* (2022)[12]	Energy-demand reduction in potato cold storage	Highlights the role of entry temperature and refrigeration management in energy efficiency.

4.1. Comparison between storage design and actual product loads

Based on actual field data, a systematic comparison should be conducted between product load estimation using standard design assumption. Such studies could establish the extent to which differences in loading quantity, loading duration, product temperature and cooling duration affect the required refrigeration capacity.

4.2. Role of product load in refrigeration system

The relationship between product load and the performance of design parameters like compressor, evaporator, condenser, refrigerant pipelines and pressure vessels require further investigation. In particular, studies should examine whether installed equipment can accommodate the maximum product load under actual loading conditions and whether capacity control measures can improve part-load efficiency as well as compressor performance.

6. Conclusion

During the initial cooling period, the load of product is a critical determinant of refrigeration demand in a commercial potato cold storage. Its magnitude depends on the mass of potatoes, their initial temperature, specific heat, loading rate, loading pattern etc. Previous research demonstrates that the loading schedule and cooling rate can substantially influence refrigeration demand and moisture loss. Accordingly, refrigeration capacity should not be assessed solely on the basis of total storage capacity or assumed loading conditions. Instead, the actual quantity and temperature of incoming potatoes, their distribution within the chamber and the time required to achieve suitable storage conditions should be incorporated into the assessment.

Future research should focus on developing of reliable methods for estimation of refrigeration load of product and validating their accuracy under actual field conditions of a commercial potato cold storage. Combining assessments of product load with measured the performance of refrigeration system as well as storage-losses data would facilitate more appropriate of equipment sizing, improved energy management and better preservation of potato quality. The ultimate goal should be to optimize energy consumption while maintaining the required storage conditions, preserving product quality and minimizing post-harvest losses.

References

1. Anonymous. Cold storage for fresh horticulture produce not requiring pre-cooling before storage (Technical Standard No. NHB-CS-Type 01-2010). National Horticulture Board, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India. 2010.
2. ASHRAE. Refrigeration systems and applications. In: ASHRAE handbook. Atlanta (USA): ASHRAE. 1990.
3. Chourasia MK, Bandyopadhyay A, Bhadra A, Goswami TK. Estimation of transient refrigeration load in potato cold store. In: Proceedings of the International Conference on Emerging Technologies in Agricultural and Food Engineering. 2004:156-164.
4. Chourasia MK, Goswami TK. CFD simulation of effects of operating parameters and product on heat transfer and moisture loss in the stack of bagged potatoes. Journal of Food Engineering. 2007;80(3):947-960.
5. Chourasia MK, Goswami TK. Product-cooling load and moisture loss under different loading patterns and cooling rates of potatoes in cold storage. Journal of Food Process Engineering. 2008;31(3):339-353.
6. Chourasia MK, Goswami TK, Chowdhury K. Temperature profiles during cold storage of bagged potatoes: Effects of geometric and operating parameters. Transactions of the ASAE. 1999;42:1345-1351.
7. Chourasia MK, Maji P, Baskey A, Goswami TK. Estimation of moisture loss from the cooling data of potatoes. Journal of Food Process Engineering. 2005;28(4):397-416.
8. Czerko Z, Zarzyńska K, Boguszewska-Mańkowska D. Postharvest physiology and storage of potato. Potato production worldwide. Academic Press. 2023:261-272.
9. Eltawil M. Performance and economic evaluation of solar photovoltaic powered cooling system for potato storage. Agricultural Engineering International: The CIGR Journal. 2007.
10. Khatun R, Chourasia MK, Dhali K. Analysis of refrigeration load in potato cold storage under practical operating conditions. International Journal of Agriculture and Food Science. 2026;8(4):37-41.
11. Mercier S, Villeneuve S, Mondor M, Uysal I. Time–temperature management along the food cold chain: A review of recent developments. Comprehensive reviews in food science and food safety. 2017;16(4):647-667.
12. Sáenz-Baños M, Latorre-Biel JI, Martinez-Camara E, Longo F, Blanco-Fernandez J. Methodology for energy demand reduction of potato cold storage process. Journal of Food Process Engineering. 2022;45(10):1-13.
13. Thompson JF. Pre-cooling and storage facilities. The commercial storage of fruits, vegetables, and florist and nursery stocks. 2004;11:34.
14. ur Rehman H, Jabeen N, Qaisrani TB, Sufyan M, ur Rahman MZ, Zahra A, Aziz H. Role of Post-Harvest Management and Value Addition in Preserving Potato Quality and Supporting Sustainable Processing. Planta Animalia. 2026;5(2):87-100.

2664844X.2026.v8.i1.1b.89773, 2026, 8(1), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i1.1b.89773 by International Journal of Agriculture and Food Science on [04/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

15. Zhen Q, Xu C, Tana, Wang H, Yue X, Yan C, Sun Y. Research on the temperature and humidity distribution characteristics in potato storage facilities: experimental analysis and numerical simulation. Frontiers in Sustainable Food Systems. 2025;9:1594791.

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