Design and Development of a Warm and Well-Organized Food Delivery Bag

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ABSTRACT

The rapid growth of online food delivery has increased the need for delivery containers that can protect food quality while remaining practical for motorcycle-based riders. This study presents the design and development of a Warm and Well-Organized Food Delivery Bag intended to improve thermal retention, beverage stability, internal organization, and rider usability. A user-needs questionnaire involving 38 food delivery riders was first used to identify shortcomings of existing bags. A conceptual design process incorporating a morphological chart was then applied to select the external form, closure system, beverage-holder configuration, and internal partitioning. The resulting prototype combines an Oxford-fabric exterior, insulated interior layers, an integrated heating pad powered by a rechargeable power bank, a dedicated power-bank compartment, a digital temperature indicator, and a redesigned three-cup holder with a roller feature. Prototype performance was evaluated through repeated temperature measurements at 10-minute intervals and through rider-based usability assessment. The recorded temperature tests reached maximum values of 37.4°C and 37.5°C at approximately 100–110 min, while the power-bank operating duration was approximately 4 h 40 min. Six riders participated in the structured rating assessment and reported a 100% positive overall evaluation of the prototype, with particularly favourable responses for ease of use, usefulness, product quality, design, and heat level. The results demonstrate the feasibility of integrating thermal assistance and functional organization into a motorcycle-oriented food delivery bag. However, the measured temperatures remain below commonly cited hot-holding benchmarks; therefore, the prototype should be regarded as a thermal-retention and warming aid rather than a validated food-safety hot-holding device. Further work should investigate controlled food-core temperature measurements, insulation performance, battery efficiency, thermal uniformity, and larger-scale rider trials.

Keywords: food delivery bag, thermal retention, product design, rider usability, insulated packaging

INTRODUCTION

Online food delivery has evolved into an important component of contemporary urban food-service systems. The expansion of app-based delivery has changed not only how customers obtain meals but also the operational conditions experienced by delivery riders. Recent studies show that riders must manage time pressure, route constraints, customer expectations, platform requirements, and operational uncertainty while completing last-mile deliveries [1–3]. Consequently, the delivery container is more than a passive carrying accessory: it is an operational interface between the restaurant, rider, and customer.

Maintaining food quality during last-mile transportation is particularly challenging because delivery time, ambient conditions, packaging configuration, and handling practices interact. Recent research on online food delivery has identified the maintenance of meal quality and hygiene as important components of service quality and customer satisfaction [4]. Studies using consumer-generated reviews likewise indicate that food quality and delivery-related attributes remain central to customers' perceptions of online food delivery performance [5]. Packaging therefore has a direct practical role in preserving the condition of food while it is transported.

Thermal management is a critical design consideration for food-delivery containers. The use of low-conductivity insulation can reduce heat transfer and slow temperature change, while active heating can provide additional thermal compensation when passive insulation alone is insufficient. Recent engineering research has demonstrated the feasibility of integrating thermal-management technologies into vehicle-oriented food-delivery boxes, including systems capable of both heating and cooling [6]. At the same time, packaging research continues to emphasise the need to balance thermal performance, functional protection, usability, and sustainability in last-mile food delivery [7].

Despite these developments, conventional rider bags commonly prioritise carrying capacity and basic insulation, with less attention given to beverage stability, internal organization, direct temperature monitoring, and rider-oriented ergonomics. The preliminary questionnaire used in this study identified recurring concerns involving food temperature, limited space, water or beverage spillage, and insufficient organization. The present study therefore addresses a product-design gap by developing a multifunctional delivery bag that combines passive insulation, active warming, compartmentalization, beverage stabilization, and temperature monitoring within a motorcycle-oriented form factor.

The objective of this study is to design, fabricate, and preliminarily evaluate a Warm and Well-Organized Food Delivery Bag based on identified rider requirements. The study specifically investigates: (i) user-reported shortcomings of existing delivery bags; (ii) the translation of those requirements into a morphological product concept; (iii) the fabrication and integration of the thermal and organizational features; and (iv) preliminary thermal and user-based performance of the prototype.

METHODOLOGY

User-needs questionnaire

The preliminary user-needs study was conducted to identify shortcomings in existing food delivery bags and to establish design requirements for the prototype. Questionnaire items were distributed through social-media and messaging platforms, including Instagram, Facebook, Twitter, and WhatsApp. The respondent group comprised 38 food delivery riders from different companies and genders. The questionnaire focused on insulation-related issues, functional limitations, and opportunities for improvement. The resulting response distribution was used as an input to the conceptual design process.

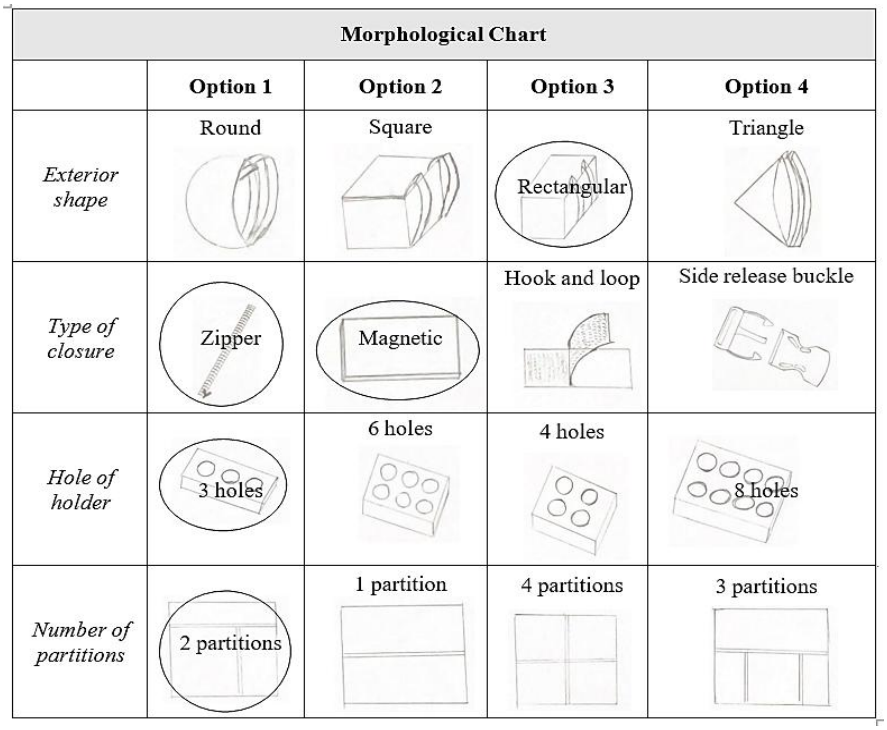

Figure 1. Preliminary questionnaire results on shortcomings of existing food delivery bags.

Concept development and morphological analysis

A morphological design approach was adopted to systematically generate and compare alternative solutions for the principal functions of the bag. Four design alternatives were considered for each major design variable, including external shape, closure type, beverage-holder configuration, and internal partitioning. The final concept was selected by considering the identified user needs, manufacturability, functional integration, and practical use by motorcycle riders.

Design variable	Option 1	Option 2	Option 3	Option 4
Exterior shape	Round	Square	Rectangular	Triangle
Closure type	Zipper	Magnetic	Hook and loop	Side-release buckle
Beverage-holder holes	3 holes	6 holes	4 holes	8 holes
Internal partitions	2 partitions	1 partition	4 partitions	3 partitions

Table 1. Morphological chart used for concept generation and selection.

Prototype design and fabrication

The selected design was developed as a three-dimensional CAD concept and subsequently translated into a detailed drawing for fabrication. The prototype uses an Oxford-fabric outer shell with an insulated internal lining. The bag incorporates two internal divisions that create three functional zones for food and beverages. A three-cup holder with a roller-type support was introduced to reduce beverage movement and the associated risk of spillage. Two adjustable double-side buckle clips are positioned to improve stability when the bag is mounted on a motorcycle.

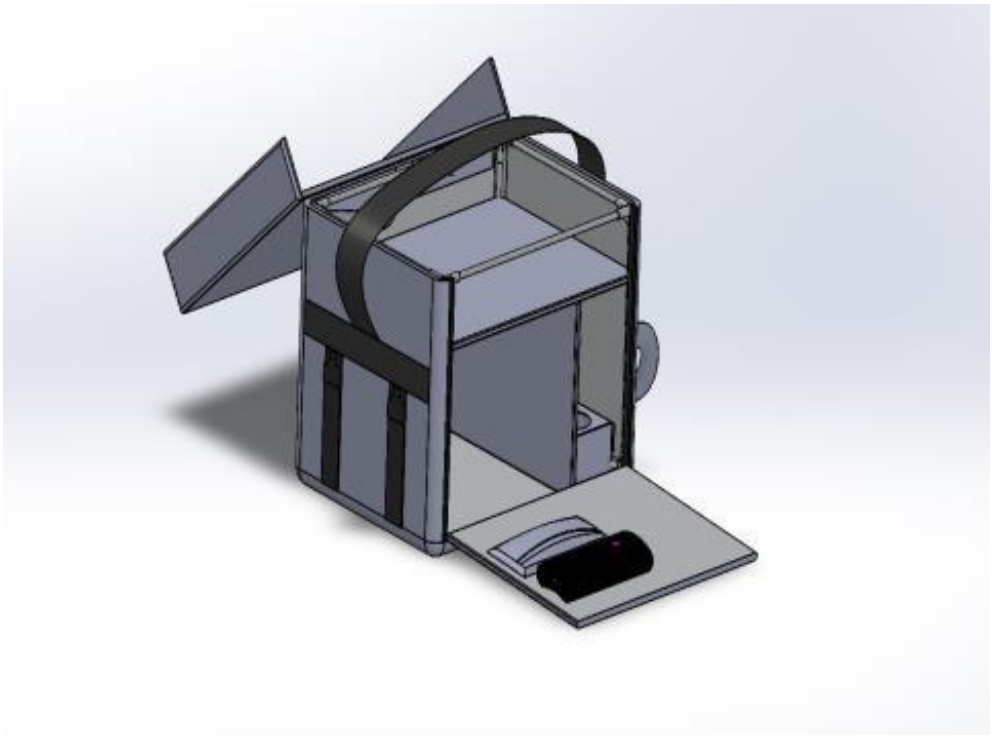

Figure 2. Three-dimensional CAD model of the final delivery-bag design.

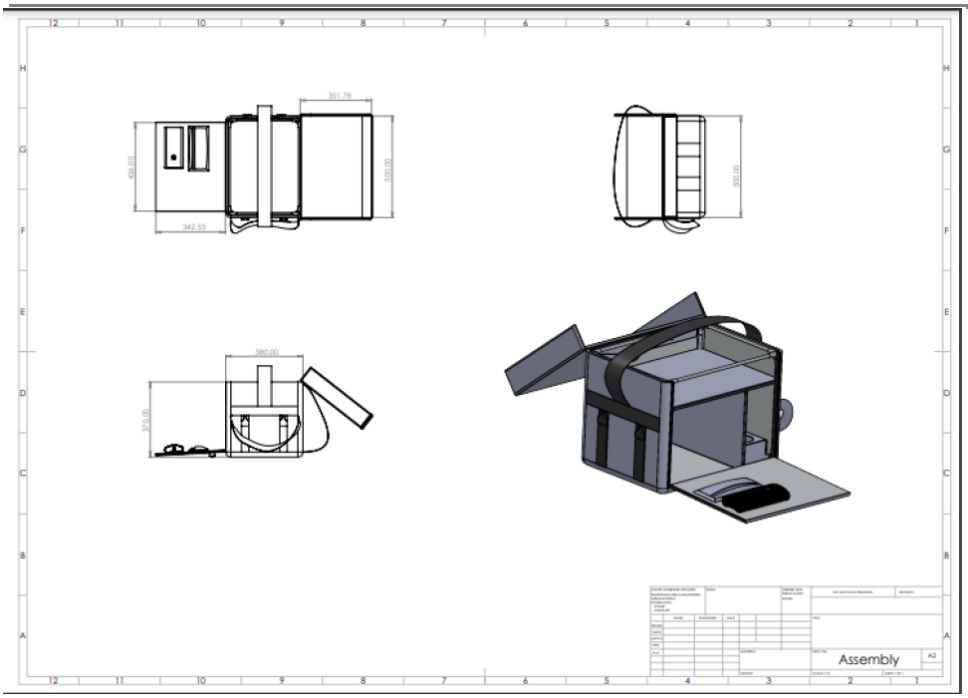

Figure 3. Detailed drawing and assembly representation of the final design.

Fabrication began with measurement and cutting of the textile and insulation layers according to the detailed drawing, followed by sewing and assembly of the structural components. The divider, beverage holder, and power-bank compartment were subsequently integrated. A heating pad was installed within the insulated interior and powered by a rechargeable power bank stored in a dedicated waterproof compartment. A digital thermometer was mounted externally and connected to the internal measurement point to enable real-time temperature monitoring.

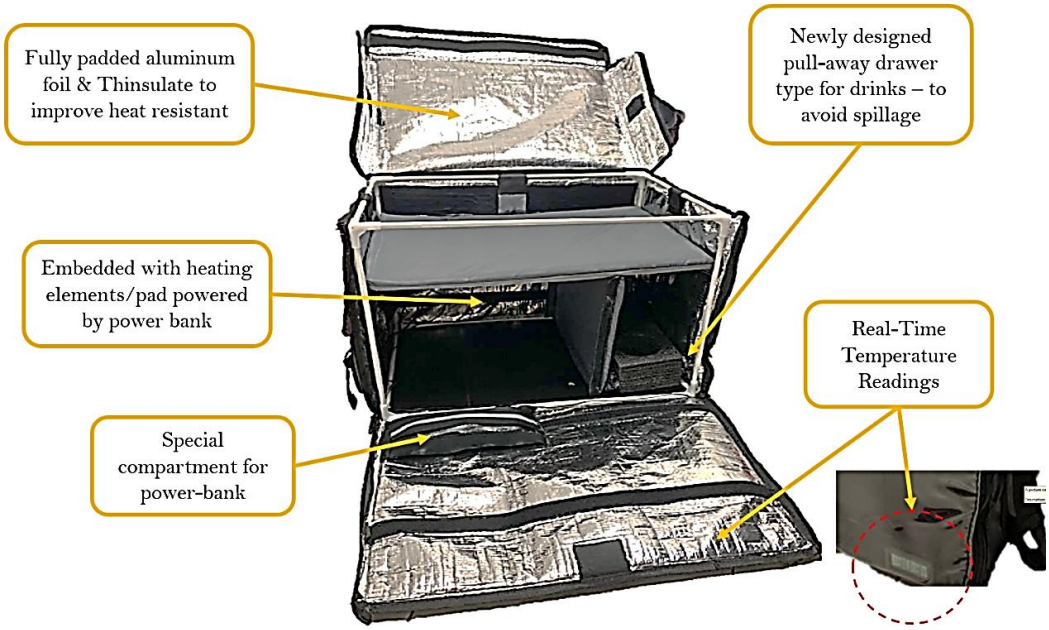

Figure 4. Exterior and functional features of the developed prototype.

Figure 5 illustrates the internal configuration of the prototype, including the insulated lining, integrated heating pad, power-bank compartment, beverage drawer/holder, and temperature-monitoring arrangement. The design emphasizes modular access to food and beverages so that riders can retrieve items without unnecessarily disturbing the other contents.

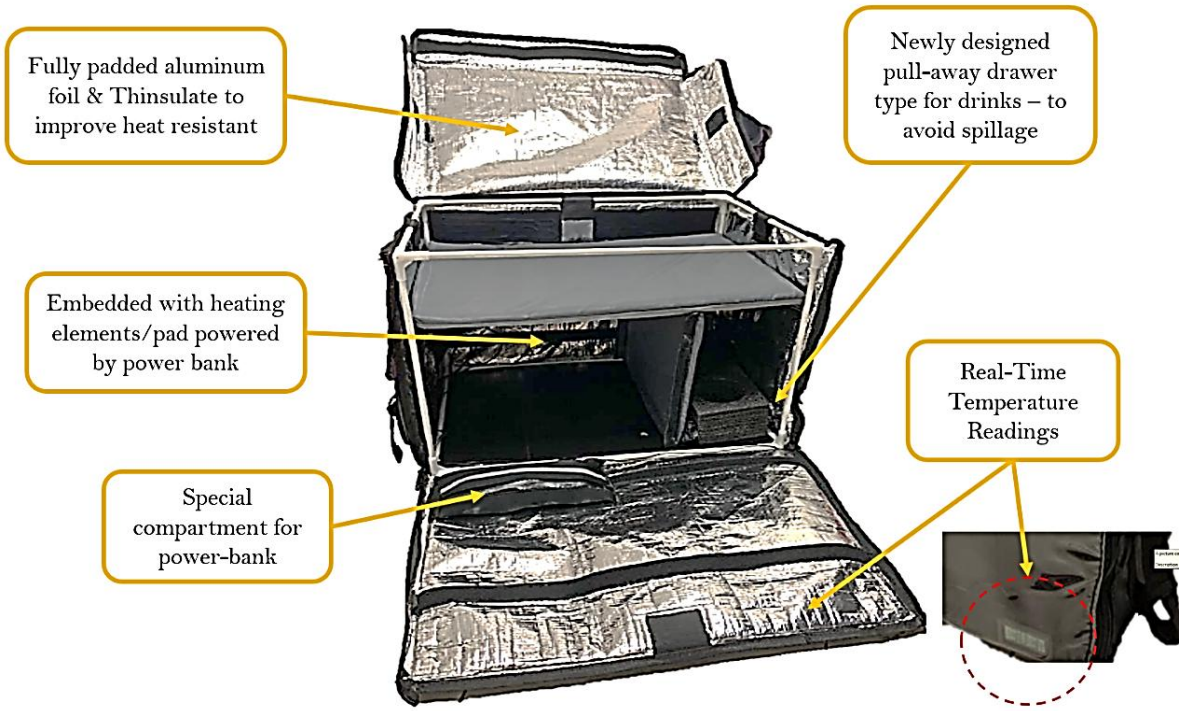

Figure 5. Interior configuration and integrated functional features of the prototype.

Thermal performance test

Thermal performance was assessed by recording the bag temperature at 10-minute intervals during operation of the integrated heating system. Two temperature-test datasets were obtained from the prototype. The heating system was powered by a rechargeable power bank, with an observed operating duration of approximately 4 h 40 min. Measurements were continued until the available battery power was depleted. The resulting temperature-versus-time profiles were used to evaluate the thermal response and retention behaviour of the prototype.

Rider-based usability evaluation

Following prototype fabrication and thermal testing, rider feedback was collected using a structured rating questionnaire. Six riders participated in the overall rating exercise. The assessed attributes included comfort, usefulness, reliability, ease of use, product quality, liability as reported in the original questionnaire, stability, value for money, design, heat level, and available space. A separate field trial involved three riders who used the prototype during food-delivery activity and subsequently provided feedback on its practical performance. Because the sample size was small and purposive, the results are interpreted as preliminary usability evidence rather than statistically generalizable population estimates.

RESULTS AND DISCUSSION

Thermal response of the prototype

The two temperature profiles demonstrate a repeatable warming response. In the first dataset, the temperature increased from approximately 30°C at the start of the test to a maximum of 37.4°C at 100–110 min before gradually declining. In the second dataset, the temperature increased to a maximum of 37.5°C at approximately 100 min and subsequently decreased. The broadly similar peak values suggest that the prototype provides a measurable warming effect under the tested conditions, although the available data do not establish the temperature of the food core itself.

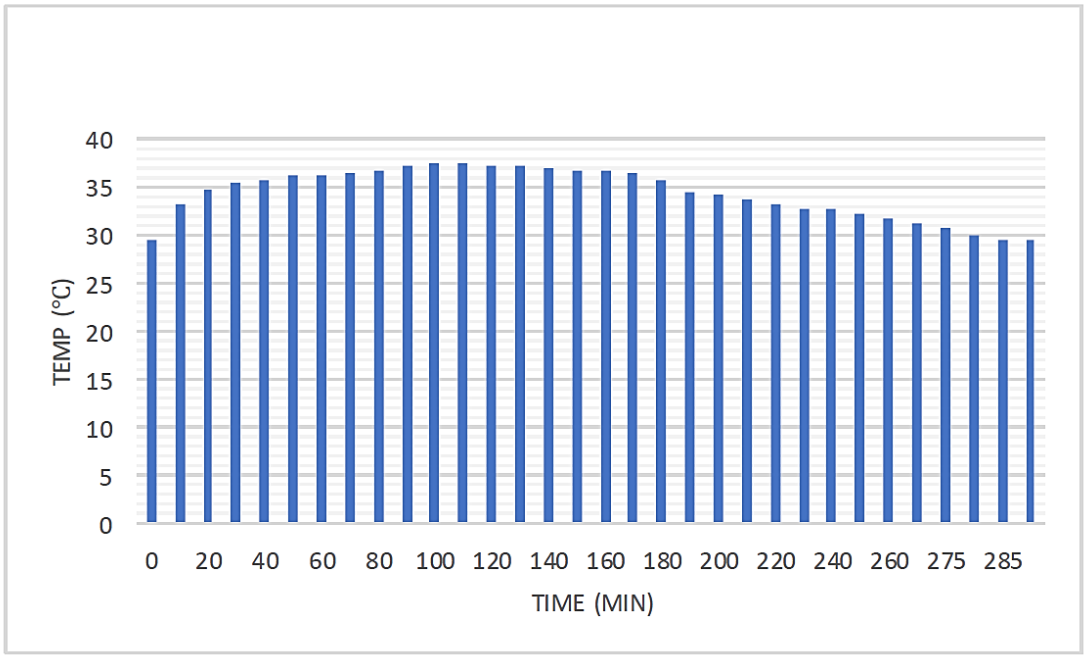

Figure 6. Temperature response of the prototype: Dataset 1.

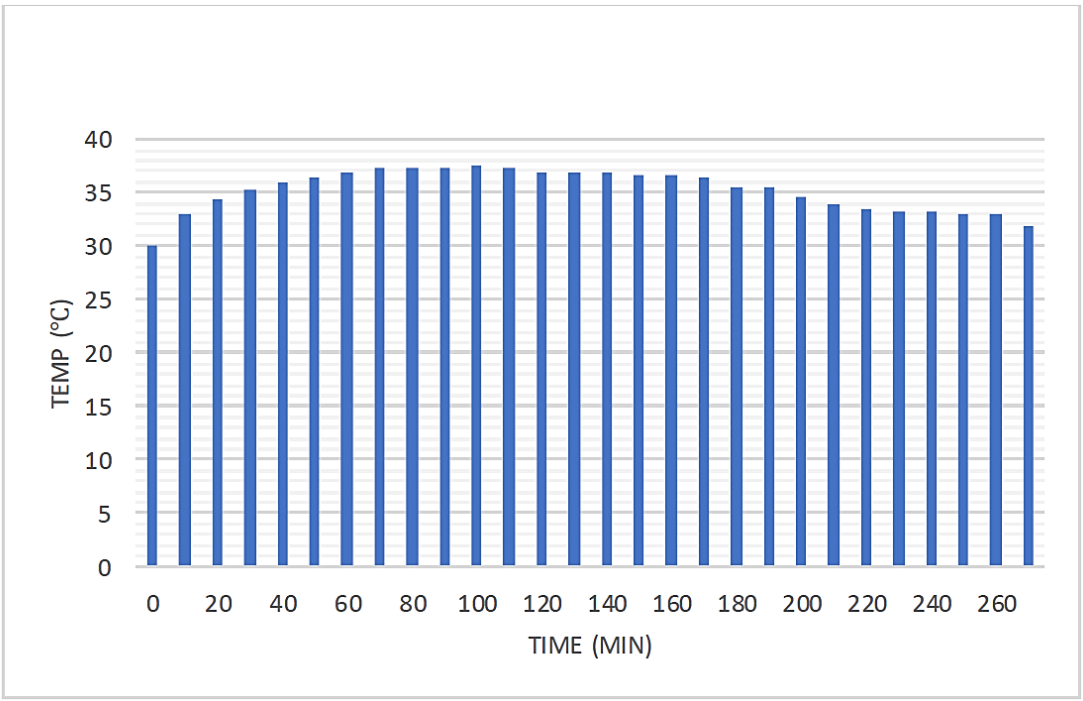

Figure 7. Temperature response of the prototype: Dataset 2.

The measured peak temperature of approximately 37.4–37.5°C should be interpreted carefully. The result confirms thermal assistance but does not demonstrate compliance with a hot-holding requirement. For example, the FDA Food Code identifies 57°C (135°F) as the hot-holding temperature for applicable time/temperature-control food in the United States [8]. Accordingly, the present prototype should not be claimed as a validated food-safety preservation device. Instead, its current technical contribution is better positioned as a rider-oriented thermal-retention and warming system. Future experiments should measure actual food-core temperature under controlled loads, ambient conditions, delivery durations, and food types.

The observed decline after the peak is also consistent with the combined effects of insulation losses, ambient heat transfer, and the reduction in available electrical energy. A more rigorous thermal characterization

should therefore include empty-bag and loaded-bag tests, temperature mapping at multiple locations, ambient-temperature logging, heat-input measurement, and energy consumption per unit time. These additions would allow the prototype to be compared quantitatively with passive insulated bags and commercial active-heating systems.

Rider satisfaction and usability

The structured rider evaluation produced a favourable preliminary response. All six participating riders provided a positive overall assessment of the prototype, corresponding to 100% positive evaluation in the original scoring exercise. The strongest responses were associated with ease of use, usefulness, product quality, design, and heat level. The findings indicate that the prototype addressed several functional pain points identified during the initial needs assessment.

Attribute	Rating 1	Rating 2	Rating 3
Comfort	2	3	1
Useful	3	3	0
Reliable	1	4	1
Easy to use	5	1	0
Product quality	3	3	0
Liability*	1	4	1
Stability	1	4	1
Value for money	2	4	0
Design	3	3	0
Heat level	3	2	1
Space in bag	1	3	2

Table 2. Distribution of rider ratings reported in the original evaluation (n = 6).

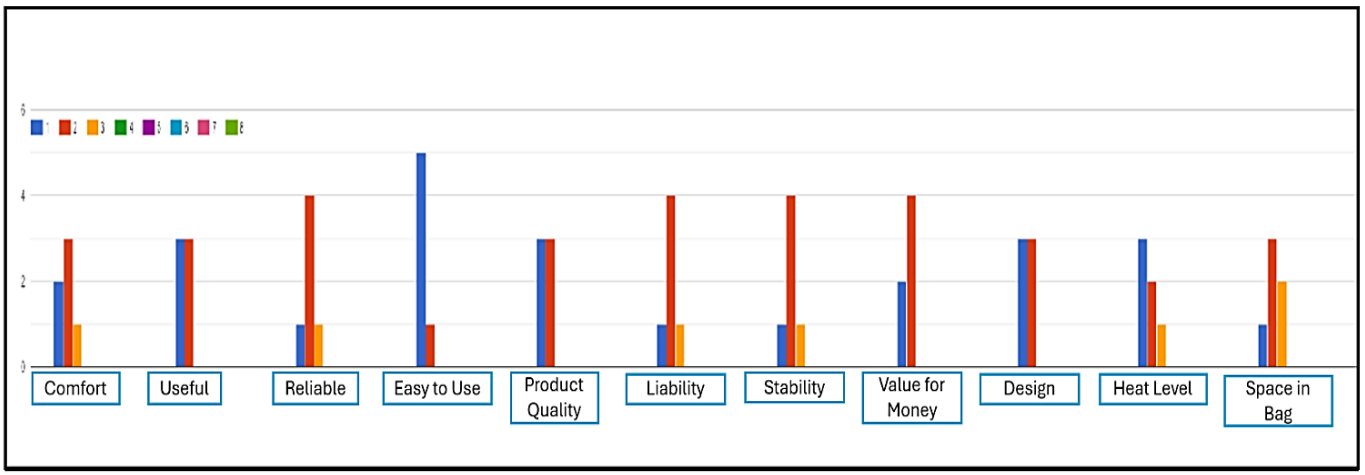

Figure 8. Rider rating profile across the evaluated prototype attributes.

From a product-design perspective, the favourable ratings are important because they suggest that the prototype's value is not restricted to thermal functionality. The integrated beverage holder, internal partitions, power-bank compartment, and external temperature display collectively improve task organization. This is consistent with recent studies showing that delivery experience, ease of use, food quality, and rider-related attributes influence satisfaction in online food delivery services [4,9]. The present prototype extends that service-quality perspective into the physical product used during the last-mile delivery process.

Prototype field-test feedback

Three riders subsequently participated in the field trial, including riders associated with major Malaysian food-delivery platforms. The field trial focused on practical use during delivery preparation and transportation. The rider profiles and supporting evidence in the original manuscript indicate that the prototype was evaluated in an actual motorcycle-delivery context rather than only in a laboratory setting. The field feedback therefore provides useful preliminary evidence of operational feasibility, although the small sample limits statistical inference.

Field-test participant	Platform/context reported	Assessment focus
Rider 1	Food-delivery rider	Practical handling and delivery use
Rider 2	Food-delivery rider	Bag stability and usability during riding
Rider 3	Food-delivery rider	Prototype use and overall practicality

Table 3. Summary of the three-rider field-test group reported in the original study.

The field-test observations support the feasibility of the integrated design but also highlight the need for a more rigorous validation protocol. A future study should recruit a larger and more diverse rider sample, compare the prototype against a commercial control bag, and collect objective measures such as food-core temperature, thermal decay rate, beverage leakage incidence, loading time, rider-reported workload, and battery energy consumption. Such comparative evidence would strengthen the engineering contribution and improve the reproducibility of the evaluation.

CONCLUSION

This study developed a multifunctional food delivery bag designed around the practical requirements of motorcycle-based last-mile delivery. A preliminary needs assessment involving 38 riders informed the concept-development process, after which a morphological chart was used to select the final configuration. The resulting prototype integrates insulated construction, an active heating pad, rechargeable power supply, dedicated power-bank storage, real-time temperature indication, internal partitions, and a three-cup beverage holder with a roller-type support.

Two preliminary thermal tests produced maximum recorded temperatures of 37.4°C and 37.5°C, while the power-bank operating duration was approximately 4 h 40 min. The six-rider evaluation produced a 100% positive overall response, with favourable ratings for usability, usefulness, product quality, design, and heat level. These findings indicate that the prototype can improve the organization and practical handling of food and beverages during delivery while providing an additional warming function.

Nevertheless, the measured temperature range remains below a 57°C hot-holding benchmark used in established food-safety guidance [8]. The prototype should therefore not be represented as a validated food-safety hot-holding system. The principal outcome of the present work is the demonstration of a feasible, rider-oriented product architecture that combines thermal assistance with improved organization and beverage stability. Future research should focus on controlled food-core temperature testing, thermal

uniformity, insulation characterization, energy efficiency, comparative benchmarking against commercial bags, and larger-scale field trials.

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