A Study on the Performance of Commercial Lithium Batteries in Philippine Online Markets

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A Study on the Performance of Commercial Lithium Batteries in Philippine Online Markets

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Abstract: *This study evaluates the actual capacity and cost-effectiveness of 18650 lithium-ion batteries sold through major Philippine online platforms, specifically Shopee and Lazada. Focusing on commonly advertised 3Ah and 2Ah models, 90 battery samples from 30 different sellers were tested using an Arbin Battery Tester and MITS Pro 8 software under standardized laboratory conditions. Results reveal that many 3Ah-rated batteries significantly underperformed, with some delivering less than 30% of their advertised capacity, indicating widespread mislabeling or counterfeit products. In contrast, most 2Ah-rated batteries met or exceeded their rated capacities, with brands such as PKCell-S, Joinsun, LiiToKala, and Pinyou demonstrating both high performance and cost-efficiency. The findings underscore the urgent need for stricter quality control, transparent product labeling, and consumer awareness to ensure the reliability and safety of lithium-ion batteries purchased online in the Philippines.*

Keywords: 18650 Lithium-Ion Batteries; Battery Performance Evaluation; Battery Capacity Testing; Battery Cost per Ampere-hour; Battery Quality Assessment

1. INTRODUCTION

The increasing global demand for portable electronic devices and electric tools has driven the need for reliable and efficient energy storage solutions. Among the various energy storage technologies available, lithium-ion (Li-ion) batteries have emerged as the preferred choice due to their high energy density, long cycle life, and relatively low self-discharge rate. These characteristics make Li-ion batteries especially suitable for modern technological applications where compactness and efficiency are essential.

One of the most widely adopted forms of Li-ion batteries is the 18650 cylindrical cells, named after their physical dimensions: 18 mm in diameter and 650 mm in length. These batteries are commonly found in laptops, flashlights, electric bicycles, power banks, and even in battery packs of electric vehicles such as Tesla's [1].

In the Philippine context, the rise of online shopping platforms such as Lazada and Shopee has made it easier for consumers to purchase 18650 batteries. While this increased accessibility has benefited many users, it has created fertile ground for questionable products to reach consumers. Some battery sellers and manufacturers cut production costs by using lower-grade materials, weak safety mechanisms, and inadequate quality control processes. As a result, batteries sold in these platforms may deliver far less capacity than advertised, degrade faster over time, or even present hazardous failure modes.

Poor-quality 18650 batteries have been linked to dangerous incidents, including fires, explosions, and severe injuries. These batteries can overheat and reach temperatures exceeding 700°C, sometimes turning into high-speed projectiles during catastrophic failures. In 2018, a tragic incident occurred when a man died due to a vape pen explosion, which was later traced to a faulty 18650 batteries [2].

In 2020, 2,693 e-cigarette explosions and burn injuries were recorded, many of which were linked directly to unsafe or mishandled 18650 lithium-ion cells [3]. Due to such risks, major battery manufacturers explicitly state that their 18650 lithium-ion cells are intended for use in protected battery packs with a Battery Management System (BMS) or Protection Circuit Board (PCB), and not for standalone use by consumers. They warn that improper handling or misuse can lead to fire, explosion, or thermal runaway, and that these batteries should not be used in devices like e-cigarettes or vaporizers.

Given these growing concerns, the need for performance evaluation and quality verification of 18650 batteries in the local market has become urgent. While some sellers provide detailed specifications, the accuracy and reliability of such claims remain questionable. There is a clear gap in consumer protection, as many buyers lack access to technical means of validating battery capacity and safety features. In this context, empirical testing of battery performance plays a crucial role in promoting transparency and accountability in the marketplace.

This study aims to evaluate the performance and actual capacity of 18650 lithium-ion batteries available in the Philippine online market using a precision battery testing system, specifically the Arbin Battery Tester with MITS Pro 8 software. By subjecting each battery sample to standardized charge and discharge cycles under controlled laboratory conditions, the study seeks to accurately measure the delivered capacity and verify the accuracy of the advertised specifications. Additionally, the research determines these batteries' cost per ampere-hour (Ah) to assess their cost-effectiveness in the local online market. This comprehensive evaluation provides valuable insights into the reliability, quality, and economic value of 18650 lithium-ion batteries sold through Philippine e-commerce platforms, helping consumers make informed purchasing decisions.

2. METHODOLOGY

This study followed an experimental protocol informed by prior research on battery performance testing, particularly the standardized evaluation frameworks established by Muenzel et al. [4] and the Holistic

Characterization procedures proposed by Zatta and Catenaro [5,6]. These references provided proven techniques for charge-discharge cycling, averaging for capacity calculation, and environmental control during testing.
Quantitative experimental design was employed. A total of 90 battery samples were purchased from Shopee and Lazada, covering 30 stores. Each battery underwent dimension and weight testing, followed by four charge-discharge cycles using an Arbin Battery Tester with MITS Pro 8 software. The initial discharge cycle was excluded from analysis, and the average capacity of the subsequent three cycles was calculated to assess actual battery performance. Additionally, price data were collected to determine the cost per ampere-hour (₱/Ah).

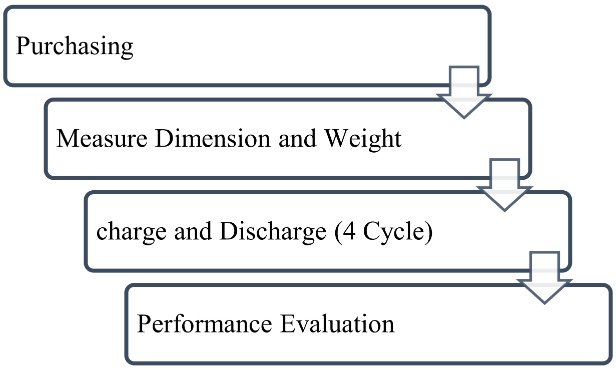

Fig. 1. Research Design and Methodology for evaluating 18650 lithium-ion battery.

Figure 1 presents a comprehensive flowchart outlining the systematic research design and methodology employed in this study to evaluate the performance of 18650 lithium-ion batteries sourced from Philippine online marketplaces. The process begins with the identification of target products using relevant keywords such as "lithium-ion battery" and "18650 cells," ensuring that the batteries selected for testing reflect the typical options available to local consumers. Once identified, the batteries are purchased from various online platforms, primarily Shopee and Lazada, to capture a representative sample of the market.
Upon receipt, each battery undergoes dimension and weight verification using an analytical balance and precision caliper. This step is crucial for confirming that the physical specifications align with manufacturer claims and for detecting any discrepancies that might indicate counterfeit or substandard products. The batteries are then prepared for electrochemical testing using a custom 3D-printed cell holder, which ensures secure placement and reliable electrical contact during subsequent charge and discharge cycles.
The methodology's core involves subjecting each battery to four complete charge-discharge cycles using the Arbin Battery Tester and MITS Pro 8 software under controlled laboratory conditions. The initial cycle is excluded from analysis to account for any stabilization effects, while the subsequent three cycles are averaged to obtain a reliable measure of actual capacity. This approach minimizes anomalies and enhances the accuracy of performance assessment.
The final stage of the methodology involves calculating the cost per ampere-hour (₱/Ah) based on the actual measured capacity and the purchase price of each battery. This metric provides a practical basis for evaluating the cost-effectiveness of different brands and models, allowing for meaningful comparisons from a consumer perspective.
Overall, the flowchart in Figure 1 encapsulates a rigorous and repeatable protocol for battery evaluation, integrating both physical and electrochemical characterization. By following this structured approach, the study ensures that the results are both reliable and directly relevant to end-users seeking trustworthy and economical battery options in the Philippine online market.
The tests were conducted in the Battery Testing Laboratory of the Center for Renewable Energy, Automation, and Fabrication Technologies (CRAFT) by using the following major equipment, as shown in Figure 2.
1. The MITS Pro Software, running on a computer, acts as the command center. It enables users to program battery test parameters and visualize the real-time current (I(t)) and voltage (V(t)) data acquired from the testing process. Communication with the Arbin Testing System occurs via a TCP/IP Connection.
2. The Arbin Testing System is the core hardware responsible for executing the programmed tests. It applies controlled currents to the battery and meticulously measures the resulting current, I(t), flowing through it, as well as the voltage, V(t), across its terminals. This crucial data is then transmitted back to the MITS Pro software.
3. A 3D Self-made Battery Holder provides the necessary Physical Connection to the battery under test. This custom fixture ensures secure placement and reliable electrical contact, allowing the Arbin system to effectively charge and discharge the battery while accurately measuring its electrical characteristics. The image shows a design tailored for a cylindrical battery.

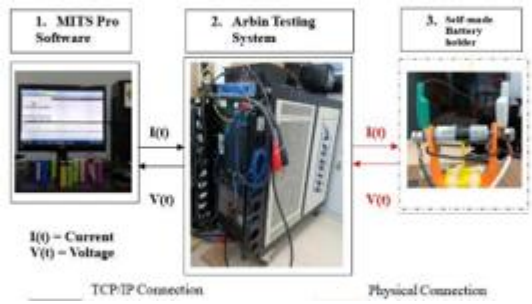

Fig. 2. Experimental setup and physical connections

2.1. Capacity Determination
To evaluate the dependence of the cell capacity on the temperature and discharge current, as in [7-9], the following testing procedure was implemented:
1. Fully charge the cell to SoC = 100% with
   (a) 1C constant current (CC) until the voltage reaches the upper cut-off (4.2V) and
   (b) constant voltage (CV) until the current decreases to the rate C/20.
2. Rest the cell voltage for 1 hour.
3. Discharge the cell with CC at a rate C/20 until the voltage decreases to the lower cut-off of 2.5V.
4. Rest for 1 hour
5. Repeat steps 1-4 five times.

Each cycle displays a distinct pattern of charging and discharging over time. The positive current intervals correspond to the charging phase, during which voltage gradually increases toward the upper cutoff (typically around 4.2V). Conversely, the negative current intervals represent the discharging phase, where voltage steadily declines to the lower cutoff limit (usually around 2.5–3.0V). These repeated cycles highlight the battery's performance consistency and provide visual confirmation of its energy storage and release characteristics under controlled conditions.

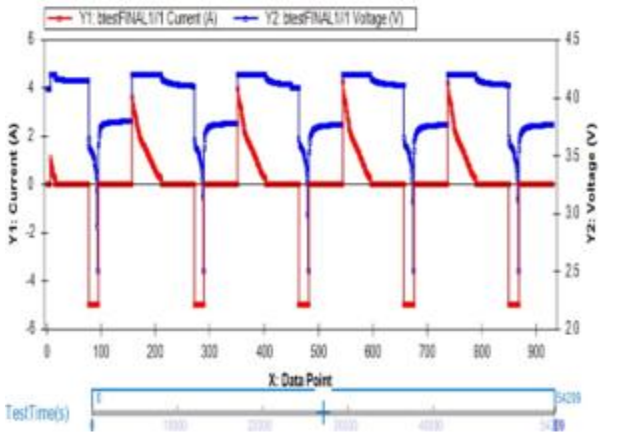

Fig. 3. Current and Voltage vs. Time During Charge-Discharge Cycles.

Figure 3 presents the charge-discharge cycling profile of a tested 18650 lithium-ion battery, as recorded using the Arbin Battery Tester with MITS Pro 8 software. The graph simultaneously plots current (in amperes, red curve, left Y-axis) and voltage (in volts, blue curve, right Y-axis) against data points corresponding to elapsed test time (X-axis).

Each cycle in the figure consists of a charging phase, where the current is positive and the voltage gradually increases, followed by a discharging phase, where the current becomes negative and the voltage decreases. The consistent, step-like patterns observed in both current and voltage traces over multiple cycles indicate a stable and repeatable charging and discharging process under controlled laboratory conditions.

During charging, the current is held constant until the battery voltage approaches its upper limit (around 4.2 V), after which a voltage hold is observed as the current tapers off—characteristic of a constant current-constant voltage (CC-CV) charging protocol typical for lithium-ion cells. The discharge phase shows a steady decrease in voltage as the current is drawn from the cell, with the voltage dropping to a cutoff value near 3.0 V before the current returns to zero, marking the end of each cycle.

The regularity and symmetry of the cycles suggest that the battery under test maintains stable electrochemical behavior across repeated cycles, with no significant voltage sag or current irregularities. This stability is essential for accurately determining the battery's actual capacity and assessing its reliability. Any deviations, such as abrupt voltage drops or erratic current flow, could indicate cell degradation, internal faults, or safety concerns.

Figure 3 validates the experimental methodology by demonstrating that the test conditions are well-controlled and that the battery's performance can be reliably measured for capacity and efficiency calculations. This data forms the basis for subsequent analysis of capacity retention, cost-effectiveness, and identifying potential counterfeit or substandard cells in the sample set.

3. RESULTS AND DISCUSSIONS

Table 1 presents a comparison of advertised versus actual capacities for 3Ah-rated 18650 lithium-ion batteries purchased from Philippine online markets, revealing significant discrepancies that highlight both high-performing and underperforming brands. While PKCell-S, PKCell-L, BAK, and LiiToKala batteries demonstrated excellent reliability with retention rates above 90%—and in some cases exceeding their advertised specifications—many other brands, such as MIX, Hypteq-S, Hongli, and Ume, delivered less than half of their claimed capacity, with retention rates as low as 27.3%. The inconsistent performance of LG batteries, ranging from 32.5% to 73.8% retention, raises concerns about the presence of counterfeit or misrepresented products in the market. These findings underscore the risks faced by consumers, who may unknowingly purchase batteries that are not only uneconomical but may also pose safety hazards due to poor quality and premature failure. The prevalence of such underperforming batteries calls for increased consumer awareness, stricter regulatory oversight, and the implementation of standardized third-party testing to ensure product quality and market integrity.

Table 1. Summary of Test Results for 3Ah Batteries

Brands	Advertised Capacity	Actual Capacity	%Retention
LiiToKala B1	3 Ah	2.83 Ah	94.5 %
PKCell-S B3	3 Ah	3.04 Ah	101 %
Panasonic B3	3 Ah	2.67 Ah	89.1 %
MIX B3	3 Ah	0.84 Ah	29.5 %
PKCell-L B2	3 Ah	3.04 Ah	101 %
Hongli-S B1	3 Ah	1.21 Ah	40.4 %
Hongli-S B2	3 Ah	1.24 Ah	41.4 %
Hongli-S B3	3 Ah	1.21 Ah	40.6 %
Hongli-L B1	3 Ah	1.17 Ah	39.6 %
Hongli-L B2	3 Ah	1.16 Ah	38.8 %
Hongli-L B3	3 Ah	1.12 Ah	37.6 %
Hypteq-S B1	3 Ah	0.81 Ah	27.3 %
Hypteq-S B2	3 Ah	1.05 Ah	35.2 %
Hypteq -S B3	3 Ah	0.83 Ah	27.7 %
Hypteq -L B1	3 Ah	1.5 Ah	50.2 %
Hypteq -L B2	3 Ah	1.5 Ah	46.2 %
Hypteq -L B3	3 Ah	1.46 Ah	51.1 %
Ume B1	3 Ah	1.16 Ah	38.8 %
Ume B2	3 Ah	1.06 Ah	35.5 %
Ume B3	3 Ah	1.02 Ah	34.3 %
BAK B1	3 Ah	2.88 Ah	96.1 %
BAK B2	3 Ah	2.77 Ah	92.4 %
BAK B3	3 Ah	2.85 Ah	95 %
LG B1	3 Ah	2.21 Ah	73.8 %
LG B2	3 Ah	1.71 Ah	57.1 %
LG B3	3 Ah	1.87 Ah	32.5 %

Table 2 summarizes the actual versus advertised capacities of 2Ah-rated 18650 lithium-ion batteries from various brands, showing that nearly all tested samples closely matched or exceeded their claimed specifications. Brands such as PKCell-S, Joinsun, and Pinyou notably outperformed expectations, with retention rates consistently above 100%, indicating accurate labeling and a margin of surplus capacity. MST, Sony, Sanyo, and Samsung batteries also demonstrated high reliability, with actual capacities averaging above 93% of their advertised ratings, reflecting strong manufacturing quality and trustworthy product representation. These results contrast sharply with the findings for 3Ah-rated batteries, suggesting that 2Ah models from reputable brands available in the Philippine online market are generally reliable and offer consumers both value and performance as advertised.

Table 2. Summary of Test Results for 2Ah Batteries

Brand	Advertised Capacity	Actual Capacity	%Retention
MST B1	2 Ah	2.02 Ah	101 %
PKCell-S B1	2 Ah	2.37 Ah	11 8%
Joinsun B1	2 Ah	2.19 Ah	100.5 %
Joinsun B2	2 Ah	2.21 Ah	107 %
Joinsun B3	2 Ah	2.2 Ah	104 %
Pinyou B1	2 Ah	2.06 Ah	103.35 %
Pinyou B2	2 Ah	2.06 Ah	103.3 %
Pinyou B3	2 Ah	2.09 Ah	104.7 %
Sony B1	2 Ah	1.94 Ah	97.45 %
Sony B2	2 Ah	1.9 Ah	96.85 %
Sony B3	2 Ah	1.9 Ah	96.05 %
Sanyo B1	2 Ah	1.88 Ah	94.5 %
Sanyo B2	2 Ah	1.94 Ah	97.25 %
Sanyo B3	2 Ah	1.87 Ah	93.95 %
Samsung B1	2 Ah	1.94 Ah	96.95 %
Samsung B2	2 Ah	1.88 Ah	94.3 %
Samsung B3	2 Ah	1.88 Ah	93.85 %

Fig. 4. Summary chart of Price/Advertised Ah vs Price/Actual Ah of 3Ah Batteries

Figure 4 presents the comparative analysis of the price/advertised and price/actual Ah of various 18650 batteries sold online in the Philippines. The blue bars represent the Price/Advertised Ah, based on a standard 3Ah claim, while the orange bars show the Price/Actual Ah calculated from verified capacity measurements. A prominent trend observed is that the Price/Actual Ah is generally higher than the advertised values, indicating that many batteries underperform in real usage compared to their listed specifications.

Among the tested batteries, LiiToKala B1 displayed a relatively minor discrepancy between its price/advertised Ah and price/actual Ah, suggesting that it delivers performance close to its advertised 3Ah capacity. This makes LiiToKala B1 a cost-effective and reliable option for consumers.

Similarly, batteries such as Hongli-L B1, Hongli-L B2, and Hypteq-L B1 also showed low actual price per Ah, making them some of the most economical choices in the dataset. On the other hand, brands like Hypteq-S B1, Hypteq-S B2, and UME-B1 had extremely high actual prices per Ah, reaching nearly ₱200, which reveals a significant shortfall in actual capacity and positions them as the least economical options.

Moderate performers included LG B1, LG B2, LG B3, BAK B1, BAK B2, and Panasonic B3, which had fair but noticeable gaps between advertised and actual values. Batteries like UME B2 and Hypteq-L B2 also demonstrated average performance, balancing affordability and reliability.

This highlights that many 18650 batteries available online in the Philippines fail to meet their advertised capacity, leading to underestimated cost per Ah values. For consumers aiming to get the best value, it is crucial to consider both advertised claims and verified performance. Brands such as LiiToKala B1, Hongli-L, and Hypteq-L stood out as more dependable choices. At the same time, options like Hypteq-S and UME presented the poorest cost-efficiency due to exaggerated capacity ratings.

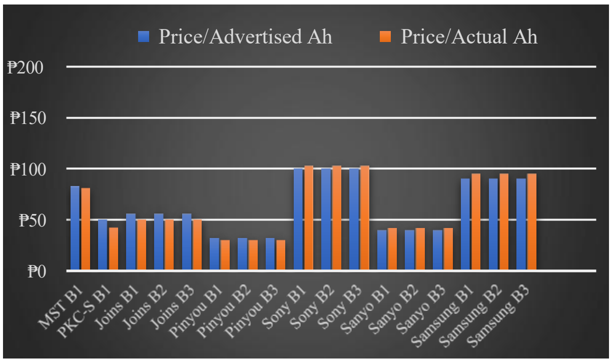

Fig. 5. Summary chart of Price/Advertised Ah vs Price/Actual Ah of 2Ah Batteries

Figure 5 presents the comparative assessment of the Price/Advertised and Price/Actual cost per ampere-hour (₱/Ah) of various 18650 batteries rated at 2Ah and sold online in the Philippines.

In this analysis, the blue bars indicate the Price/Advertised Ah, while the orange bars reflect the Price/Actual Ah derived from verified capacity measurements. In contrast to the previously analyzed 3Ah batteries, this set of 2Ah batteries shows smaller discrepancies between the Price/Advertised Ah and Price/Actual Ah. The data suggests that, overall, manufacturers or sellers of these 2Ah batteries tend to provide more accurate or conservative capacity claims, resulting in more reliable cost expectations for consumers.

Batteries such as Sony B1, Sony B2, and Sony B3, along with Sanyo B1, B2, and B3, exhibited almost identical price/advertised and price/actual Ah values. This consistency implies high honesty and precision in their capacity ratings. However, it is worth noting that these brands also had some of the highest absolute prices per Ah among all tested units. This aligns with their high

performance and quality reputation, but at a premium cost.
On the other end of the spectrum, Pinyou B1, B2, and B3 stood out for having some of the lowest price/actual Ah values. Their price/advertised and price/actual values were close, which indicates that these batteries deliver near their claimed capacity and offer good value for money.
Similarly, Joinsun B1–B3 and Samsung B1–B3 displayed relatively modest gaps between their price/advertised and price/actual Ah's, reflecting a reasonable balance between performance and pricing. Although MST B1 had slightly higher discrepancies, it was not as pronounced as the outliers observed in the 3Ah battery group.
In summary, the cost per Ah for the 2Ah-rated 18650 batteries is generally more consistent with advertised claims than what was observed in the 3Ah category. This suggests greater reliability and truthfulness among sellers of 2Ah batteries in the Philippine online market. Brands like Sony, Sanyo, and Samsung provide reliable, though premium-priced options, while Pinyou emerges as a particularly cost-effective choice with honest capacity ratings. Consumers can be more confident in the value they receive when purchasing 2Ah batteries compared to 3Ah batteries.

4. SUMMARY OF FINDINGS

This study systematically evaluated the actual capacity and cost efficiency of 18650 lithium-ion batteries sold through Philippine online marketplaces, focusing on both 3Ah and 2Ah-rated models. The results revealed a pronounced disparity between advertised and actual battery capacities, particularly among 3Ah-rated products. While reputable brands such as PKCell, BAK, LiiToKala, and Panasonic demonstrated high accuracy—with retention rates typically above 90% and, in some cases, exceeding their rated capacities—numerous brands, including Hongli, Hypteq, Ume, and MIX, consistently delivered less than half of their claimed capacity. Some units, such as MIX B3 and Hypteq-S B1, exhibited retention rates as low as 27–30%, strongly suggesting mislabeling, use of degraded cells, or counterfeit products. LG and Panasonic batteries showed moderate but inconsistent performance, raising concerns about quality control and potential rebranding of lower-grade cells.
In contrast, 2Ah-rated batteries generally offered more reliable and consistent performance. Brands like PKCell-S, Joinsun, and Pinyou not only met but frequently exceeded their advertised capacities, with retention rates ranging from 100.5% to 118%, indicating genuine specifications and robust manufacturing standards. Mainstream brands such as Sony, Sanyo, and Samsung displayed slightly conservative but stable performance, typically achieving 94–97% retention, which, while below the nominal rating, still reflects trustworthy quality.
Cost analysis further underscored the risks of exaggerated capacity claims: many 3Ah batteries with poor actual performance resulted in a substantially higher cost per real ampere-hour, misleading consumers seeking value. In contrast, 2Ah batteries, especially from Pinyou and Joinsun, delivered strong cost-effectiveness, with close alignment between advertised and actual cost per Ah. Premium brands like Sony and Sanyo maintained high price points but offered reliable, if slightly conservative, capacity.
Overall, these findings highlight the urgent need for independent validation of battery capacities and stricter marketplace oversight. Consumers are advised to favor brands with verified performance and consistent retention rates to ensure both safety and value. The study demonstrates that while some online offerings are reliable, a significant portion of the market is characterized by misrepresentation and quality concerns, especially among higher-capacity claims. Rigorous testing, transparent labeling, and consumer awareness are essential to promote safe and effective use of 18650 lithium-ion batteries in the Philippines.

5. CONCLUSION AND RECOMMENDATIONS

This study evaluated the performance and cost-efficiency of 18650 lithium-ion batteries sold in Philippine online markets, revealing critical discrepancies between advertised claims and real-world performance. For 3Ah-rated batteries, brands like PKCell-S, BAK, and LiiToKala demonstrated high reliability, with retention rates exceeding 90% and, in some cases, surpassing advertised capacities. However, many brands, including Hongli, Hypteq, and MIX, delivered less than 50% of their claimed capacity, with units like MIX B3 and Hypteq-S B1 performing at just 27–30% retention. Such severe underperformance suggests widespread mislabeling, counterfeit practices, or the use of degraded cells, posing significant economic and safety risks for consumers.
In contrast, 2Ah-rated batteries exhibited greater reliability, with brands like PKCell-S, Joinsun, and Pinyou consistently exceeding their specifications (up to 118% retention). Even mainstream brands such as Sony and Sanyo delivered stable performance, retaining 93–97% of their rated capacity. This disparity highlights that 2Ah batteries sold online in the Philippines are generally more trustworthy, offering better alignment between advertised and actual performance.
Economic analysis further underscored the risks of exaggerated capacity claims. Many 3Ah batteries with poor retention rates resulted in inflated costs per usable Ah, some exceeding ₱190/Ah, effectively misleading cost-conscious buyers. In contrast, 2Ah batteries like Pinyou and Joinsun provided superior cost-efficiency, with minimal gaps between advertised and actual ₱/Ah values.
While this study primarily focused on verifying the actual capacity and cost-effectiveness of 18650 lithium-ion batteries sourced from Philippine online markets, it is important to interpret the results in the context of electrothermal effects. Arsalan and Farzaneh's[10] work demonstrates that both high temperatures and elevated discharge rates can lead to increased capacity loss through mechanisms such as calendar loss (time- and temperature-dependent) and cycle loss (rate-dependent). Their semi-empirical model quantitatively predicts that capacity fade accelerates at higher temperatures and with faster discharge, which is consistent with the observed underperformance of certain battery brands in this study—especially those that may be subjected to suboptimal storage or usage conditions during shipping and handling.

The findings underscore the need for integrated thermal and electrical validation in battery quality assessments. Future studies should adopt ANSYS-based thermal modeling, as demonstrated by Qasmi et al. [11], to identify correlations between capacity retention and heat dissipation efficiency. Regulatory bodies should mandate thermal performance testing for batteries sold online, ensuring they meet safety standards comparable to professionally assembled packs.

Key Recommendations:

1. Consumer Vigilance: Prioritize brands with verified performance (e.g., PKCell-S, Pinyou) and avoid 3Ah models from sellers with inconsistent or unverified claims.
2. Regulatory Oversight: Online platforms and regulatory bodies should enforce stricter validation of capacity claims, particularly for high-capacity (3Ah+) batteries.
3. Third-Party Certification: Implement independent testing programs to verify battery performance and safety before sale, ensuring transparency in the online marketplace.
4. Seller Accountability: Mandate accurate labeling and penalize sellers engaged in fraudulent advertising.

By addressing these gaps, stakeholders can enhance consumer trust, promote safer energy storage solutions, and foster a more reliable market for lithium-ion batteries in the Philippines.

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