

Original Article

## Food Safety Knowledge and Practice in the Era of Dark Kitchens

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### Abstract

Online ordering and food product sales are well-tolerated in many countries. Post-COVID-19, the business of online food purchases has soared, and many home-based suppliers (dark kitchens) have become part of this endeavor. This practice could impact the quality and safety of the food products with the risk of adverse effects on human health arising from food-borne illnesses and spoilage. The knowledge and practice of a random sample of Mauritians on the quality and safety of locally produced processed food items was investigated. Factors that could influence the purchase of dark kitchens were also studied. Data was collected from 258 participants through a survey questionnaire in March 2022. Up to 99.2 % reported that food suppliers should adhere to hazard analysis critical control points and international standard operation to guarantee quality. The study indicated that 45% of the respondents purchased from dark kitchens. Inadequate scores for both knowledge and practice were noted. The correlation between knowledge and practice was moderate ( $\tau = 0.088$ ;  $p = 0.00$ ). Furthermore, it was observed that dark kitchen' purchases were motivated by easy accessibility, food quality, and low prices. Food labels were reported as an important characteristic of food products in general. However, in practice, only 31% reported labels and 27.1% reported the site of preparation as an important factor when they decide on the site of purchase. The participants were aware of hygienic practices, the impact of unsafe food on their health and the importance of food standards. Yet, purchases from unchecked sources remain prominent. By fostering awareness and understanding, behavioral changes among individuals could be investigated, contributing to an overall improvement in public health and preventing food-related illnesses.

**Keywords:** Dark kitchens, Food Safety and Quality, Hygienic Practices, Local Food.

### INTRODUCTION

Foodborne illnesses are increasingly reported globally. The foodborne pathogens may cause mild to severe symptoms such as diarrhoea and meningitis<sup>1</sup>. Foodborne illnesses have also been associated with a significant rise in disability, morbidity and mortality<sup>2</sup>. Foodborne disease is largely preventable if food safety is not compromised. About 1 in 10 individuals suffer from illness, more than 600 million people fall ill and 420 000 die annually after consuming contaminated food<sup>3</sup>. Foodborne illnesses are commonly associated with enteric syndromes and sometimes extend to other systems. More than 90% of patients afflicted by foodborne diseases experience diarrheal

symptoms. Many cases go unreported due to mild symptoms, limited public awareness, underreporting procedures and the lack of laboratory detection. These factors consequently pose challenges in estimating the true burden of foodborne diseases, delay outbreak detection and response, and hinder the implementation of effective food safety policies that could enhance food safety<sup>4</sup>.

Outbreaks originating in households, typically involve individuals or a limited number of people, making them less likely to be identified by public health authorities. Consequently, the proportion of foodborne outbreaks and individual cases originating in homes is likely greater than reported<sup>5</sup>.

The occurrence of two or more instances of similar illnesses resulting from the consumption of a shared food source characterises a foodborne disease outbreak<sup>6</sup>.

As per the European Food Safety Authority, 95% of cases of foodborne diseases originated from small outbreaks that started within households<sup>7</sup>. Furthermore, 12-17% of outbreaks of foodborne illness in England and Wales started in households. *Salmonella* and *Campylobacter* infections in home kitchens might be closer to 50-80%<sup>8</sup>. Foodborne illnesses disproportionately affect developing nations due to substandard living conditions, inadequate personal hygiene, and limited access to proper living conditions<sup>9</sup>.

Modern society is experiencing innovations due to various challenges and emerging conditions. Swift adoption of smartphones, application technologies, and internet access have reshaped how individuals allocate their time to daily activities, including the time allocated for food preparation<sup>10</sup>. The COVID-19 pandemic has increased the availability of ready-to-eat foods on online websites. This has led to a noticeable rise in cost-effective business models and a shift from traditional brick-and-mortar stores to online services and catering to consumers in diverse situations<sup>10</sup>. This trend has attracted the attention of prominent players in the food delivery industry. The growing inclination of customers towards ordering food for delivery or takeout, as opposed to dining in person, has spurred the emergence of dark kitchens<sup>11</sup>.

Previously, the dark kitchen was defined as restaurants that do not have storefronts, do not interact with customers directly, and are delivery-only industrial kitchens that rent out communal or private kitchen premises to food enterprises<sup>10</sup>. This paradigm had been present for many years but has recently gained popularity owing to technological developments, the consequences of the epidemic and economic shifts. New dark kitchen models include home-based food suppliers<sup>12</sup>. Incorporated into the local community structure, dark kitchen indicates a fresh connection between the platformisation of urban transactions and the urbanisation of supply chain capitalism. This signifies an inconspicuous merging of cityscapes

and cyberspace that is unfolding beyond the awareness of consumers<sup>13</sup>.

Since the Covid-19 outbreak, Mauritius has also seen an increase in the online sale of food products through social media such as Facebook and TikTok. During the lockdown, many people lost their jobs and started home-based businesses to cater to the family's financial needs. The dark kitchen model in Mauritius differs as the customer deals directly with the supplier through social media. These dark kitchens remain unchecked and unknown to the health authorities. This study aimed to understand whether Mauritians are conscious about the possible health hazards that could occur with food emanating from these dark kitchens. The investigation also aimed at understanding the reasons for purchasing from these online sellers. The locally produced processed foods include a large panoply of local foods such as boulette, saomai, noodles, samosa and cutlets.

## METHODOLOGY

The survey was carried out in March 2022, after the Covid-19 lockdown. The study was approved by the Department of Health Sciences, Faculty of Medicine and Health Sciences, University of Mauritius (Ref 527/6/22). A questionnaire was designed, and an online survey was carried out. All ethical considerations were taken. The aims and objectives of the study were explained, and the participants were given a copy of the information sheet to read. They gave their consent before participating in the survey. The volunteers were assured that their data would not be divulged, and the findings of this study would be summarised in reports and used for academic purposes only.

The data was gathered using a structured questionnaire. A total of 450 individuals from the community were targeted. and the recruitment was done by google forms, which were sent via emails and social media such as WhatsApp. The number of samples was calculated as per Krejcie & Morgan (1970)<sup>14</sup>, which approximated 384 subjects for a population of 1.2 million at a confidence level of 95%. Taking into consideration the non-response rate, the number was increased to 450. A convenient sampling method was used. The participants

included individuals of various WhatsApp groups and staff of companies or institutions. Participants were asked to forward the Google form to other people.

The questionnaire was composed of four sections. The first part, section A, focused on gathering demographic information, while sections B, C and D were dedicated to participants' knowledge, attitude and practice concerning locally produced processed food products, respectively. The demographic details included gender, age group, area of residence (rural or urban), level of education (primary, secondary, tertiary or other), household income, marital status and number of family members. The household income was used to determine the socioeconomic status of the participants<sup>15</sup>.

The knowledge part included questions on awareness of the availability of locally produced processed foods in Mauritius, knowledge of Hazard analysis critical control point/ International standard operation (HACCP/ISO), importance of food regulations, factors impacting the quality of food produced, personal hygienic protocols to be followed during food preparation, effect of high microbial count in food and health consequence of consumption of food with high microbial load. The practice was about the types, frequency, and purchase site for locally produced processed food products, labelling characteristics considered during purchase and factors affecting the purchase site.

A pilot study was carried out among 25 students. The questionnaire was then reviewed and validated. The students were married, responsible for cooking at home and were enrolled for postgraduates or PhD studies at the University. The quality and suitability of the questions were assessed and finalised after making the required modifications. The responses from the experts and pilot study were not included in the final analysis. The questionnaire took approximately 8 minutes to complete.

The scoring techniques used by Madilo et al. (2020) and Soon-Sinclair (2024) were adapted and used to evaluate the responses<sup>16, 17</sup>. For each question, a score of 1 (one) was given to each correct answer, while zero (0) was given for each incorrect

answer. The score for each question was aggregated into the total score, depending on the number of answers listed. The total score for each question could range from 5 to 8. The final score for knowledge and practice was then graded into either inadequate (0-69%) or adequate (70-100%). A high knowledge or practice score would indicate a better understanding of the problem investigated. Inadequate knowledge or practice was reported when the performance was scaled at 0-69%, while adequate knowledge or practice was at 70-100%<sup>18, 19</sup>.

*Statistical analysis.* Data was analysed using IBM Statistical Package for Social Science (SPSS v 22.0). A p-value of < 0.05 was considered statistically significant. Descriptive statistics (means and frequencies) were calculated for all variables. T-test was used to compare the means between distinct groups. The correlation between two variables was assessed using Pearson correlation.

## RESULT

A total of 258 participants completed the survey. The demographic details of participants have been described in Table 1.

### Knowledge of Respondents

It was noted that 98.4% of the participants were aware of the availability of locally produced processed foods in the market and 95.3 % purchased them. Among the factors which could impact the quality of food production, 86% of respondents (n=222) reported personal hygiene of food handlers, followed by quality of raw materials (84.1%, n=217), storage of the food products (82.2%, n=212). preparation methods (79.2%, n=204), during transportation of the products (63.6%, n=164) and quality of kitchen utensils (63.2%, n=163). The knowledge on the personal hygienic protocols which should be strictly followed during food preparation were reported as avoiding coughing, sneezing, smoking or drinking alcohol in the production premises (93.8%, n=242), hand washing from time to time (92.6%, n=239), wearing of hair masks and gloves (92.5%, n=236), covering wounds or skin infections (89.5%, n=231) and wearing clean clothes (84.5%, n=218).

**Table 1.** Demographic details of participants

Demographic details	Frequency (n)	Percentage (%)	
<b>Gender</b>	Female	154	59.7
	Male	103	39.9
	Other	1	0.4
<b>Age of participants</b>	16-25 years	124	48.1
	26-35 years	33	12.8
	36-45 years	49	19.0
	> 45 years	52	20.1
<b>Place of residence</b>	Rural	180	69.8
	Urban	78	30.2
<b>Level of Education</b>	Secondary	107	41.5
	Tertiary	151	58.5
<b>Socioeconomic status</b>	High class	11	4.3
	Middle class	185	71.7
	Low class	62	24.0

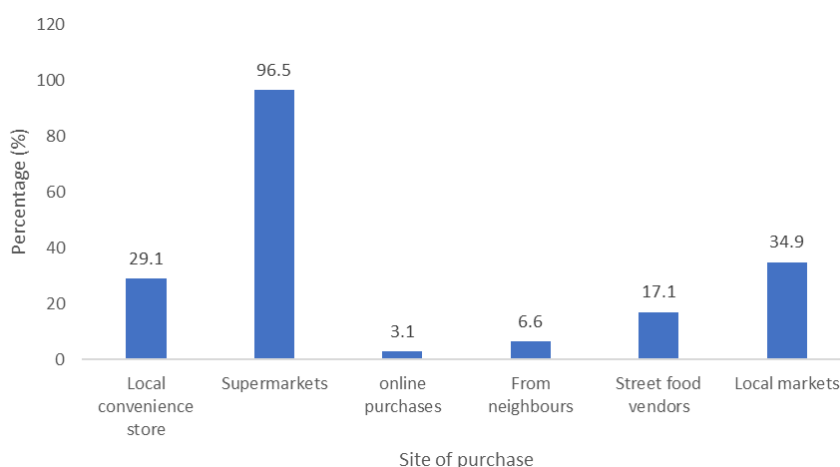
If the food is not prepared hygienically, 74.8% (n=193) of the participants reported that the microbial count would increase and there could be a change in the taste (74%, n=191), odour (57%, n=147), texture (46.9%, n=121) and colour (37.2%, n=96). Furthermore, 89.1 % (n=230) knew that consuming food products with a high microbial count would harm their health. The health consequences after consumption of such food could

be diarrhoea, as reported by 89.9% (n=232) of the respondents followed by upset stomach (88.8%, n=229), vomiting (88%, n=227), nausea (73.6%, n=190), fever (44.6%, n=115,) and loss of appetite (33.7%, n=87). Regarding knowledge about the meaning of ISO and Hazard Analysis Critical Control Points (HACCP), 60.5% of participants could relate them to standards ensuring food safety and quality. A total of 256 participants (99.2 %) reported that food suppliers should adhere to HACCP and ISO to guarantee the quality of the locally produced processed food.

It was noted that 18.6% of the participants purchased locally produced processed foods only and 80.2% purchased imported and locally produced processed food. Furthermore, 72.9% (n=188) of the respondents preferred locally produced food over imported ones.

### Practice of respondents

The nature of the locally produced processed food products was also investigated. It was found that 74 % of the volunteers purchased raw products, 51.2% semi-cooked and 28.7% cooked foods. The frequencies of the purchases also varied, where 34.1% bought the products monthly, 40.7% for special occasions, 20.2% once a week and 5% almost daily. The site of purchase ranged from local convenience stores, supermarkets, online purchases, from neighbours, street food vendors and local markets (Figure 1.).

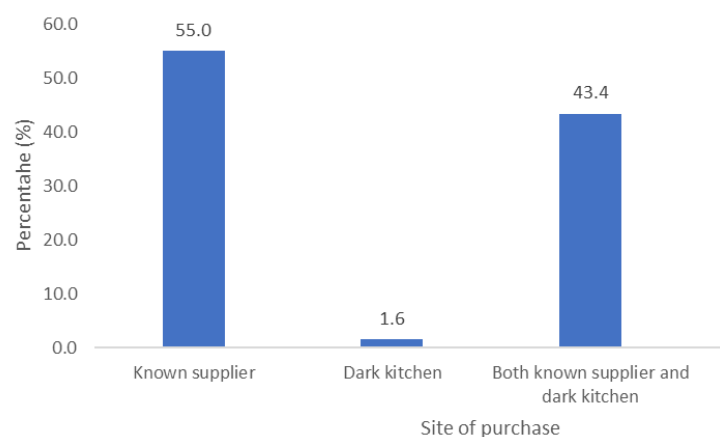
**Figure 1.** Site of purchase of the locally produced processed foods

Local convenience stores and supermarkets would sell food products, which have been produced by verified enterprises and would include a list of ingredients, date of production and date of expiry on

the package. Therefore, for this study, the purchase site was further categorised into known suppliers and dark kitchen (unknown supplier to authorities). The known supplier group included local



convenience stores and supermarkets, while dark kitchen included online purchases, neighbours, street food vendors and local markets. It was noted that purchases from dark kitchens occur at high frequency in Mauritius (Figure 2).



**Figure 2.** Comparative purchase from known suppliers and dark kitchen

The reasons for purchasing locally produced processed foods were accessibility (58.1%), quality of the product (50.8%), cheap (41.1%), and high nutrition value (33.7%). The site of purchase was affected by factors, such as labelling of the product, price of the product, site of preparation, accessibility to the site of production, health consciousness and food regulations such as ISO and HACCP (Table 2).

**Table 2.** Factors influencing choice of the purchase site

Factors reported to influence the choice of site of purchase	Number of participants (n)	Percentage (%)
Proper labelling on the product	80	31
Low price of the product	148	57.3
Site of preparation	70	27.1
Accessibility of the site	113	43.8
Health consciousness	145	56.2
Food regulations such as ISO and HACCP	124	48.1

It was noted that 191(74%) participants reported being health conscious, 56 (21.7%) were neutral and 11(4.4%) were less concerned when purchasing food products in general. However, when asked if they think about nutrition value when they purchase the locally produced processed food,

109 (42.3%) reported positively, 124 (48.1%) were neutral and 25 (9.7%) reported negatively.

The labelling characteristics which were considered when purchasing food products were the list of ingredients (93.8%), sodium content (72.5%), calorie (75.6%), vitamin content (77.5%), fat content/sugar content (86%), allergen information (78.7%), production/expiry dates (98.8%) and details of the manufacturer (67.8%).

### Knowledge and Practice score

The mean knowledge score was 68.5% and the practice score was 65.4%, indicating inadequate knowledge and practice, respectively. The findings for individual knowledge score and practice score have been described in table 3. Level of education was found to affect knowledge on factors which might impact the food quality. Those with tertiary education scored higher than those with secondary education ( $p=0.02$ ). Respondents from higher household incomes had better knowledge of health consequences upon consumption of food products with high microbial count ( $p=0.03$ ).

Those who had good knowledge on health consequences upon consuming food product with high microbial count also had similar knowledge of factors that could impact the food quality ( $p=0.00$ ). The practice score was inadequate (Table 4). The practice of considering labelling characteristics when purchasing food products, in general, was significantly associated with higher level of education ( $p=0.04$ ). Correlation between knowledge and practice was moderate ( $\tau = 0.088$ ;  $p = 0.00$ ).

### DISCUSSION

Globally, dark kitchens have flourished during and after the Covid-19 pandemic. The low cost associated with a dark kitchen makes it an appealing business model. Dark kitchen can vary from well-established online food delivery industry to home-based suppliers. Consumers are often unaware of the risks associated with poor hygiene practices and unsafe food<sup>20</sup>. From a public health perspective, this study aimed to investigate the knowledge and practice of a random sample of Mauritians on the quality and safety of locally produced processed food items. Furthermore, the investigation also aimed at understanding the reasons for purchasing from unregulated sources.

In general, up to 90% of the consumers were concerned about the quality of their food and expected that food suppliers should have good manufacturing practices. However, it was noted that 45% purchased from dark kitchens along with known suppliers. Previous studies also concluded consumers were willing to buy from dark kitchens<sup>10, 21</sup>. The ongoing evolution and expansion of the digital food environment, with the introduction of new platforms and services, are an inevitable aspect

of development globally. From an economic standpoint, the online purchase model greatly appeals to the food and gastronomy sector. For instance, in the United States, launching a traditional restaurant costs around \$ 475,500, whereas takeout and delivery-only establishments average about \$150,500. The food suppliers have no cost associated with a physical location, dine-in areas, waiters, or cashiers, so this concept reduces labour and associated cost<sup>12</sup>.

**Table 3.** Knowledge scores of respondents

Factors	Percentage of score (%)	Percentage of score (%)		p-value
		Known supplier	Known supplier and dark kitchen	
Total knowledge scores	68.5	63.9	75.4	0.00*
Knowledge score on health consequences upon consumption of food products with high microbial count	69.8	67.3	73.5	0.04*
Upset stomach	88.8	87.3	90.5	0.42
Loss of appetite	33.7	31.7	36.2	0.44
Vomiting	88	83.8	93.1	0.02*
Diarrhoea	89.9	86.6	94.0	0.03*
Nausea	73.6	71.1	76.7	0.31
Fever	44.6	43.7	45.7	0.74
Knowledge score on impact on the quality of the food when food is not prepared hygienically	58	52.2	66	0.00*
Taste	74	69.7	79.5	0.07
Texture	47	41.5	54.5	0.04*
Odour	54	52.1	64.3	0.05*
Colour	37	26.8	50.9	0.00*
Increased microbial count	75	70.4	81.2	0.04*
Knowledge score on factors that might impact on food quality	76.3	70.3	85.2	0.00*
Preparation Methods	79.9	72.5	89.3	0.00*
Quality of raw materials	84.3	81.0	88.4	0.11
Transporting the products	64.2	54.9	75.9	0.00*
Personal hygiene of food handler	86.2	79.6	94.6	0.00*
Quality of kitchen utensils	63.8	57.7	71.4	0.02*
Storage of the products	83.1	76.8	91.1	0.00*

\*Statistically significant difference ( $p < 0.05$ ) between the score of Known supplier and the score of Known supplier and dark kitchen

**Table 4.** Practice scores of respondents

Factors	Percentage score (%)	Percentage score (%)		p-value
		Known supplier	Known supplier and dark kitchen	
Total practice scores	65.4	63.8	67.5	0.15
Practice score on labelling characteristics considered when purchasing food products in general	81.4	80.7	82.1	0.64
List of ingredients	93.8	93.7	93.8	0.98
Sodium/salt content	72.5	72.5	72.3	0.97
Calorie content	75.6	76.8	74.1	0.62
Vitamin content	77.5	76.1	79.5	0.52
Fat content and sugar content	86.0	87.3	84.8	0.56
Allergen information,	78.7	77.5	80.4	0.57
Production /expiry dates	98.8	97.9	100	0.12
Details of manufacturer	67.8	64.8	71.7	0.26
Practice score on factors affecting choice of site for purchasing locally produced processed food products	44.2	41.3	48	0.12
Labels on food products	32.2	31.0	33.0	0.73
Whether produced in the food industry or home-processed	27.1	27.5	26.8	0.90
Whether food is being produced as per food regulation	48.1	47.2	50.0	0.66
Health consciousness	56.2	52.1	61.6	0.13
Low Price	57.4	50.8	64.3	0.04*
Easy access	43.8	37.3	52.7	0.01*

\*Statistically significant difference ( $p < 0.05$ ) between the score of Known supplier and the score of Known supplier and dark kitchen

Less than 50% of the participants reported that labelling, site of preparation and application as food regulation affected their choice of the purchase site, indicating that knowledge on food safety was not always implemented. Previous reports have also noted that despite having the required guidance and knowledge towards food safety, individuals did not always adopt behavioural changes<sup>22</sup>.

This study showed that many consumers diversify their food purchasing habits from dark kitchen and known suppliers. The main reasons for purchasing from dark kitchen were easy accessibility, product quality and low price. Nutrition value was among the least mentioned reason. The shift in consumer behaviour towards accepting this new food service model could also be due to satisfaction, community solidarity, or discounts. During the pandemic of Covid-19, several food businesses closed down and limited

imported food products were available. Many people resort to local food products and get acquainted with dark kitchens in the community<sup>10</sup>. These experiences might have awakened solidarity and continuous support to the local suppliers unknown to the authorities. Ray et al. (2019) reported that cashback, discounts and delivery time encouraged the consumer's online food purchase intension<sup>23</sup>. Furthermore, customer trust and satisfaction are converted into feedback, increasing the consumer's intention to buy again and word of mouth. It has also been noted that a sense of social responsibility exists in the food sector, which could influence consumer's behaviour<sup>24, 25</sup>.

It was noted that the respondents had adequate practice score (81.3%) on reading labels when purchasing food. However, it was also noted that only 31% reported that labelling the food product as an important factor could affect their choice for the

purchase site. It should be noted that locally produced processed foods from the dark kitchen do not display any list of ingredients. Madilo et al. (2020) reported a high level of importance attached to food labels information by respondents but demonstrated less understanding of the food labels when making purchasing choices, potentially jeopardising their health<sup>7</sup>. Food labels not only capture consumers' interest in stores and markets but also provide crucial details regarding food safety and nutritional content. This information allows consumers to make informed choices among food product alternatives, even when ordering through food delivery services<sup>16</sup>. As an illustration, mandatory calorie labelling in the out-of-home food sector was implemented to combat obesity<sup>26</sup>. Post Covid-19 pandemic, consumers have become more concerned about healthy diets; hence, it could explain why the respondents reported high practice scores on reading labels. However, food labelling was found irrelevant in cases where financial difficulty was present<sup>27</sup>.

Poor food safety practices could contaminate products in the food chain and cause foodborne diseases<sup>28</sup>. Several studies have implicated restaurants, households and ready to eat foods in foodborne incidents<sup>7, 29</sup>. However, the status of the practice of food safety in dark kitchens is unknown. No published study to date investigated the knowledge of the food handlers and to what extent food regulations are applied in dark kitchens.

Dark kitchens continue to operate within the informal economy, making them harder to detect and regulate. As per the law of Mauritius, all food premises should be registered, food handlers should have a valid licence and the premises should be inspected at regular intervals to ensure that food safety standards have been met. There should be enhanced monitoring and inspection procedures to deter illegal food operations. Consumers should be educated about the risks associated with unregulated food sources and encouraged to support registered food suppliers.

#### LIMITATION

The study was conducted post Covid-19 lockdown and the author, Ms Pudaruth, a university student, was studying exclusively via online

medium. Therefore, this survey could not be held face-to-face in the community. Relying solely on social media could introduce biases by excluding individuals who do not have access to these platforms. Furthermore, individuals purchasing from neighbours operating dark kitchens, which often operate outside traditional digital marketing channels, may also be overlooked. Information bias may also occur as educated people purchase from the dark kitchen, and they might provide information that aligns with social norms or expectations rather than their true behaviours.

#### CONCLUSION

Online businesses have flourished with technology, and the food industry has not spared. This study revealed that purchases from dark kitchens occur very frequently in Mauritius. Participants had adequate knowledge on hygienic practices, and factors which could impact food quality. However, the knowledge was not always implemented as the respondents purchased from dark kitchens because of low prices and accessibility. In line with these findings, the population should be educated on the importance of regulated food suppliers and the risks associated with consuming food from dark kitchens. Health authorities should regularly monitor social media to track down the suppliers. Future studies could investigate the extent to which dark kitchen operate in market, whether the supplier is the producer and perform microbiological analysis of the food purchased from the medium.

#### Conflict of Interest

The authors declared that they have no conflict of interests.

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