COOKING APPLIANCE COMPARISON FOR COMMON FOODS IN KENYA

JANUARY 2024 WORKING PAPER

eCooking Capacity Building & Market Development Programme (eCAP) eCooking Capacity Building & Market Development Programme (eCAP)

The eCooking Capacity Building & Market Development programme (eCAP) was implemented in 2023 as a partnership between Kenya Power and two UK-Aid-funded programmes, MECS and UK PACT. eCAP was managed collaboratively by Kenya Power and MECS via the STEER (Sustainable Transitions in Energy, Environment and Resilience) Centre at Loughborough University, UK and Gamos East Africa, Kenya.

Kenya Power owns and operates most of the electricity transmission and distribution system in the country and sells electricity to over 9 million customers. Kenya Power's Pika na Power (Cook with Electricity) campaign aims to stimulate demand for electricity and increase the social and environmental impacts of electricity access.

Modern Energy Cooking Services (MECS) and United Kingdom Partnering for Accelerated Climate Transitions (UK PACT) are UKAid-funded programmes with the shared vision of supporting Kenya to transition from unsustainably harvested biomass to renewably-generated electricity.

eCAP aims to accelerate the uptake of eCooking in Kenya by building the capacity of key market actors and driving forward the development of a sustainable eCooking sector by:

- Developing institutional capacity within Kenya Power
- Designing and implementing a pipeline of scalable activities in parallel with the Kenya National eCooking Strategy (KNeCS)
- Identifying pathways for scaling up the Pika na Power campaign
- Bringing together Kenya's clean cooking and electricity access sectors to empower a network of eCooking Champions
- Generating evidence on the role of eCooking as a tool for stimulating demand and increasing the social impact of electricity access to inform decision-making by Kenya Power's Board of Directors

For more information on eCAP, visit www.MECS.org.uk.

Executive Summary

According to the Kenya household cooking sector study (*MoE, 2019*), 75% of Kenyan households heavily rely on charcoal, wood, or other biomass fuels for their cooking needs. Meanwhile, about 25% utilize modern energy sources like electricity, gas, or ethanol as energy sources for cooking. Kenya has an ambitious goal to increase the use of clean cooking technologies to 100% by 2028 (MoE,*2021*). To create a strong enabling environment for this transition, the Kenyan government is working with Kenya Power and Lighting Company (KPLC) and programmes such as the UK Aid-funded Modern Energy Cooking Services (MECS), to accelerate the uptake. One of the projects contributing to the transition is the eCAP project. The project is a partnership between MECS, KPLC, and the United Kingdom Partnering for Accelerated Climate Transitions (UK PACT) aimed at building capacity and developing the market for eCooking by building upon the foundation laid by Kenya Power's Pika na Power campaign.

Figure 1: Collecting data on fuel consumption during the Controlled Cooking Tests (CCTs).

This study is one of the twelve projects under eCAP that seeks to make a comparison between commonly used household cooking appliances and their performance when cooking local Kenyan meals. The findings are from a series of Controlled Cooking Tests (CCTs) conducted in Kenya Power's Pika na Power Kitchen, where local dishes representing typical cooking practices were prepared using different fuels and devices to compare performance. The study examined fuel/energy consumption, the time taken to cook the meals, and the cost of energy. The categories of dishes included in this test include long-boiling foods (beans and beef), vegetables (spinach), and starch staples (rice, chapati, ugali, and chips). The selected dishes utilize different combinations of the three dominant cooking processes in Kenyan cuisine: boiling, shallow frying/stewing, and deep frying. The 7 dishes were each prepared across a set of 10 cooking appliances, both electrical and non-electrical. These appliances were the air fryer, hotplate, induction cooker, infrared cooker, rice cooker, ethanol stove, improved charcoal stove (ICS), liquid petroleum gas (LPG) cooker, kerosene stove, and electric pressure cooker (EPC). Ugali and beef were excluded from the analysis as they were only tested under a limited number of test conditions – ugali was only cooked on the EPC while the beef was only cooked on the EPC, LPG, and the ICS.

This study also evaluates the performance and user experience of various cooking appliances across different meals, assessing factors such as ease of use and taste. The EPC and induction stove stand out as top performers, excelling in energy efficiency, versatility, and cost-effectiveness. Their ability to cook a range of foods quickly and consume minimal energy positions them as a top choice for those seeking a cost-effective and convenient solution.

Key findings

A negative correlation is shown from the graph of the estimated monthly running cost vs the upfront cost of the appliance (Figure 2). Appliances with higher purchase prices are generally found to have lower operating costs, and thus lead to significant energy cost savings over their lifetimes. Although the air fryer has the largest upfront cost, it has one of the lowest monthly operating costs, however, this is based upon a single dish type, as its versatility is limited. The air fryer's costs are comparable only to the EPC, which has the lowest running costs of all, offering significant savings in the long term. Its efficiency is a product of merging pressure cooking with automatic control and insulation, yielding rapid cooking times and reduced energy consumption. The induction cooker and infrared cooker share the same upfront cost and are considerably cheaper than the EPC, however, of the two, the induction cooker proves to have a lower operating cost as it is more energy efficient. Although the rice cooker is specifically designed for cooking rice, it can also cook other boiled dishes. It had a similar energy consumption for rice and sukuma wiki, but while cooking beans it was much less efficient than the EPC or the induction cooker. The high heat of the LPG stove was beneficial when cooking quick-to-prepare dishes like spinach, which at a cost of Ksh 4, was like the EPC and rice cooker for this dish.

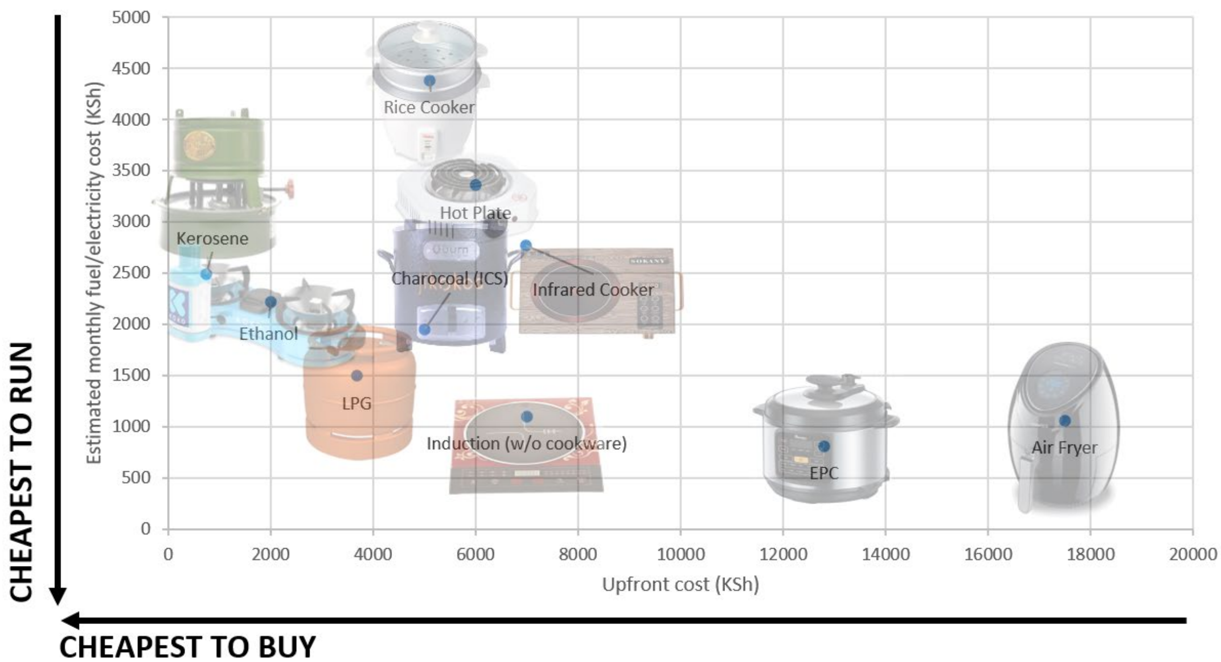

Figure 2: Comparison of upfront and estimated ongoing costs for each cooking device. Ongoing cost estimated by modeling a typical weekly menu consisting of 5 of each dish type. For appliances unable to cook all dish types (rice cooker, EPC, air fryer).

Conversely, the popular fossil fuel and biomass cooking options (kerosene, charcoal & LPG) have low financial barriers to entry, but significantly higher monthly running costs than the induction stove, EPC, or air fryer. This is primarily due to their lower energy-efficiency as heat from the open flame escapes up the sides of the cooking pot. In addition, the ethanol stove also suffers from this same issue, as do the hotplate and infrared cooker (although to a lesser extent as they do not have a flame). In contrast, the induction stove eliminates this issue by delivering heat directly to the cooking pot via electromagnetic radiation. However, the rice cooker, EPC, and air fryer all go a step further by insulating the cooking chamber to minimize convective, radiative, and evaporative losses from the cooking pot.

Figure 3 compares the estimated payback period for each of the electric appliances, showing that the induction stove and EPC have the shortest payback period. However, it should be noted that the upfront cost of the induction stove does not include compatible cookware and neither the EPC nor air fryer can cook all dishes on the menu, meaning that the payback periods for these appliances could be significantly longer. The estimated monthly cost of cooking with the rice cooker, infrared stove, or hot plate was higher than that of the baseline stack (LPG, charcoal, and kerosene), therefore there were no cost savings for these appliances.

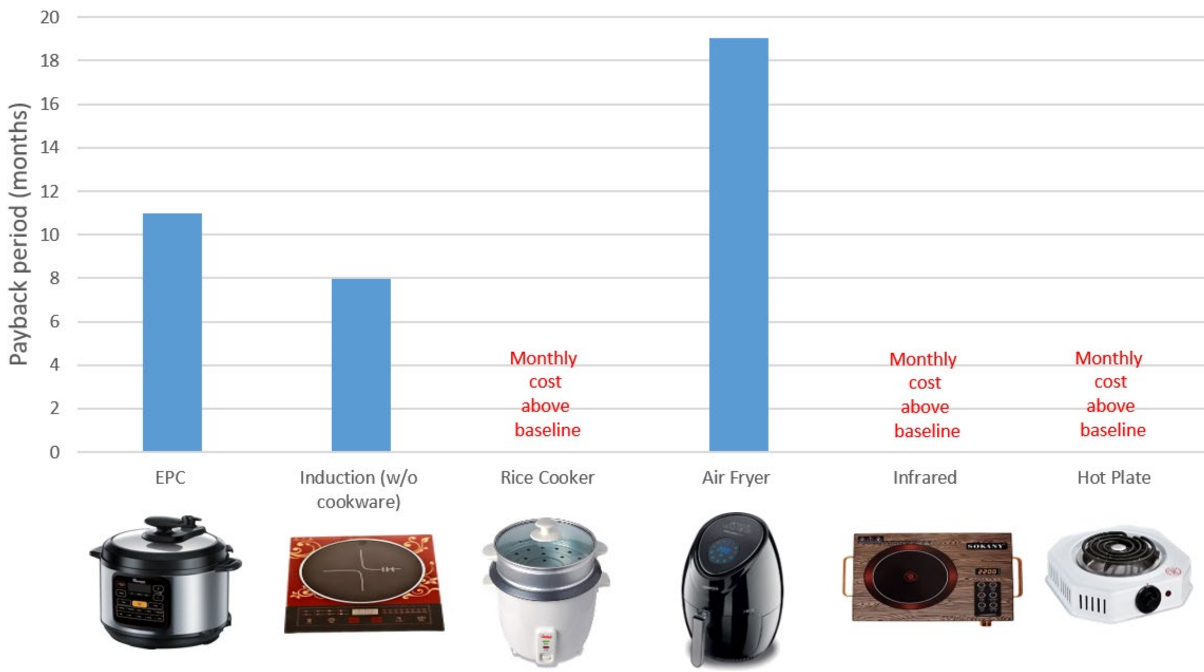

Figure 3: Estimated payback period for each of the eCooking appliances based upon a baseline fuel stack of LPG, charcoal, and kerosene (in equal parts).

This study also evaluated the performance and user experience of the various cooking appliances across different meals, assessing factors such as ease of use and taste. As shown by Figure 4 below which evaluates the energy-efficiency against the ease of use and versatility, the EPC and induction stove once again stood out as top performers. The EPC, which ranked the highest in terms of both ease of use and energy efficiency, consumes approximately one-quarter (0.21 kWh) of the average energy consumption across all appliances tested in this study (0.87 kWh). However, the induction cooker is not far behind, with an average of 0.28 kWh, and balances energy-efficiency with versatility, as whilst the EPC can only cook 3 of the 5 dish types tested in this study, the induction stove can cook all 5.

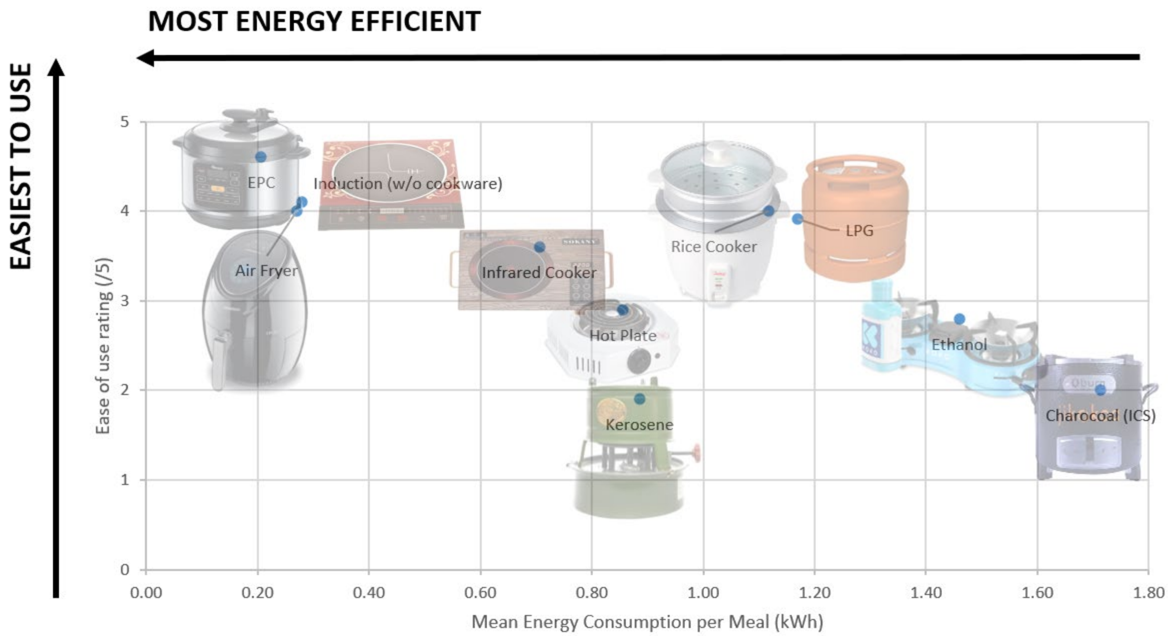

Figure 4: Evaluates the energy-efficiency against the ease of use and versatility

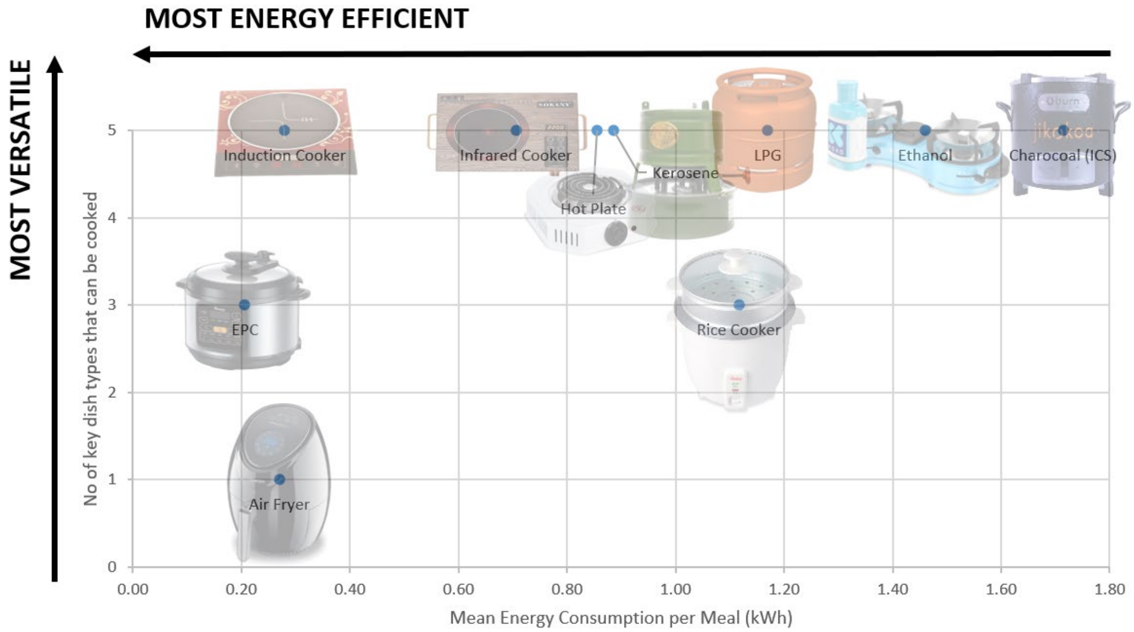

Figure 5; Energy-efficiency vs. ease of use (top) and versatility (bottom).

All the non-electric cooking fuels can cook all dish types; however, they are significantly less efficient than most electric appliances and only the LPG stove receives comparable usability scores. The ICS offers a moderate initial cost but is less energy-efficient (except for cooking chapati) with the highest average energy consumption (1.7 kWh). The kerosene and ethanol stoves both score relatively poorly as well. Although all three appliances can cook all 5 meals, this is overshadowed by their high energy use, leading to greater operating expenses and higher environmental impact compared to more energy-efficient appliances. All three traditional cook stoves had the lowest ranking on the ease-of-use score, with kerosene and ICS scoring 2 and ethanol 2.8.

Comparing the energy/cost figures from each dish type shows that the results for average energy consumption, monthly cooking cost, and payback period are dominated by each device's performance when cooking beans (Figure 4). This explains why the rice cooker seems to perform so poorly in the aggregate metrics, as whilst it performed reasonably well for rice (0.27 kWh) and spinach (0.18 kWh) it wasn't tested for chapati or chips, meaning that its overall performance ratings are marred by a very poor performance with beans (2.9 kWh). This also highlights the value of EPC, as it is most efficient at cooking the most energy-intensive meals. Whilst both appliances are insulated, the EPC cuts the cooking time in half with pressurization, and they have very different automatic control strategies. The rice cooker cooks at maximum power until the water dries out (which is regularly replenished in a dish like beans), whilst the EPC cuts the power as soon as it reaches pressure. Surprisingly despite lacking both insulation and pressurization, the induction stove is the only device that comes close to the EPC for this dish. Further investigation is needed to understand why, as other Control Cooking Test Studies like the one done by (Perros et al., 2023) have found induction stoves to be relatively energy-intensive for long boiling dishes.

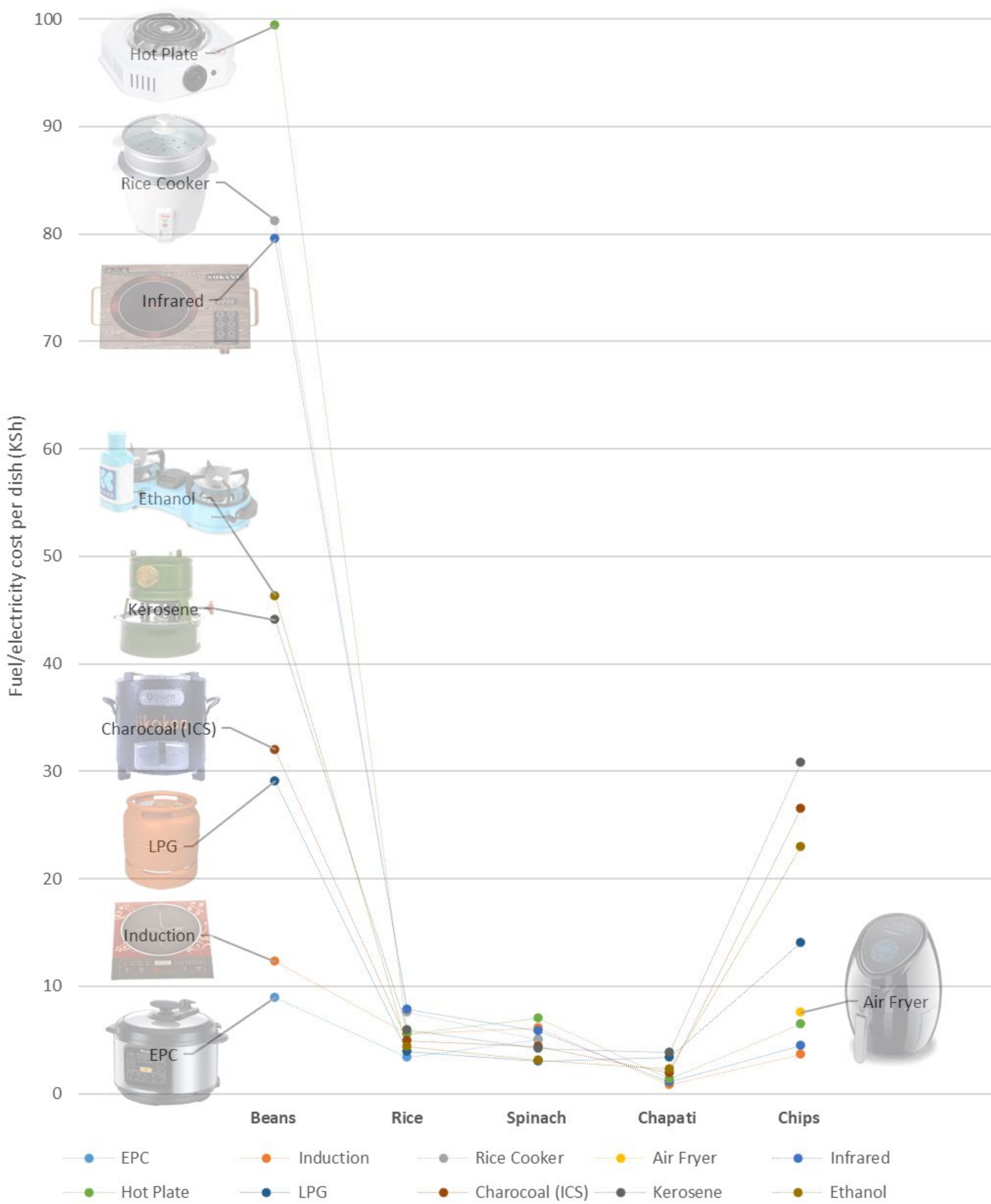

Figure 6: Comparison of the cost of cooking each type of dish with each cooking device.

The results of this study indicate that there are trade-offs to be made between upfront affordability, operational costs, and convenience, with no clear winner across all categories. This highlights the value of fuel stacking, which can enable the user to select the cooking device most appropriate for the task at hand. Table 1 below is a summary of the key learning points on each appliance tested during the study.

Table 1: Key findings from each appliance

Appliance	***Key Findings***
EPC 	**The most efficient, user-friendly, and cost-effective appliance combines pressurization, automation & insulation.** + Most efficient and cost-effective way to cook beans, rice, and spinach. + Highest score for ease of use + The quickest way to cook rice and beans. + Automation enables multitasking. – High upfront cost. – Could only cook 3 of 5 meal types.
Induction 	**Balances energy-efficiency with versatility & usability.** + 3rd most energy-efficient & cost-effective appliance: heats pot directly using electromagnetic radiation. + Quick and responsive high-power cooking. + Cooks all 5 meal types. + Used the least amount of energy, cost the least, and took the shortest amount of time to cook chapati and chips. – Moderate upfront costs, but also need to purchase compatible steel cookware. – 2nd the most energy and time-efficient appliance after the EPC when cooking beans, but still took twice as long as the EPC to cook beans.
Rice Cooker 	**Task-specific low-cost appliance for boiling & light frying with moderate energy-efficiency.** + Lower upfront cost than EPC but lacks efficiency gains of pressurization. + Cooked spinach with the least amount of energy, cost the least and took the shortest time. + Can cook more than just rice. – Only cooked 3/5 meal types. – Consumed almost twice the amount of energy and cost to cook rice compared to the EPC. Energy and cost-intensive when cooking beans.

Air fryer 	**Task-specific appliance for frying & baking with moderate energy-efficiency.** + Relatively efficient but limited to fried/baked dishes. + Uses fan-assisted hot air circulating in an insulated chamber to cook. + Vastly reduces oil consumption for deep-fried dishes. – More energy, cost, and time-intensive than the hot plate, induction, and infrared to cook chips. – Could only cook one meal type. – Highest upfront cost.
Infrared Cooker 	**Highly versatile, but energy-intensive appliance.** + Distributes heat very evenly across the pan as heat is transferred through infrared radiation, like charcoal. + Can use all cooking utensils. + Able to cook all five meal types. + More energy efficient than an air fryer for chips & similar efficient to a rice cooker for rice. – Slow response to changes in heat level. – Highly inefficient for boiling heavy foods like beans.
Hot Plate 	**Highly versatile low-cost, but energy-intensive appliance.** + Simple resistive heating element. + Can use all cooking utensils. + Able to cook all five meal types. – Most expensive and time-consuming electrical appliance to cook beans with. – The quickest, but most expensive to cook rice.

Table 2: Key findings from each non-electric cooking device.

Cooking device	***Key Findings***
LPG 	+ Easily adjustable flame control & instant on/off. + Suitable for a wide range of cooking methods; boiling, simmering, and frying. + Most energy-efficient non-electrical cooking appliances are when cooking beans, rice, spinach, and chapati. + Cost-efficient for cooking rice. + Cost less than the rice cooker, hot plate, and infrared cooker when cooking beans. – More energy-intensive and expensive to cook with than the most efficient electric appliances

Charcoal (ICS) 	+ Can cook all 5 meals. + Compared to conventional charcoal stove: improved safety and minimal heat loss due to the enclosed combustion chamber. + Cost-effective and time-efficient for cooking chapatti and costs the least to cook beans (non-electrical). – Energy intensive compared to energy-efficient electric appliances. – Inefficient & slow lighting process. – Difficult to adjust the heat level.
Kerosene 	+ Most cost effective when cooking chips amongst the non-electrical appliances. + Adjustable heat output. – Relatively slow. – Energy intensive and expensive for cooking chapati, rice, and spinach. – Produced soot during cooking. – Gave an unpleasant, smoky taste and gritty texture to the dishes. – It ranked the lowest in terms of ease of use amongst most dishes.
Ethanol 	+ Only clean burning fuel tested. + Adjustable heat output. + Fuel safety mechanisms. – Most energy-intensive (non-electrical) to cook hard foods like beans. – Expensive to cook chips. – Relatively slow.

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Introduction

The availability and affordability of clean and sustainable cooking practices are critical challenges faced in Kenya. The prevalence of wood fuel (charcoal and firewood) as the primary cooking fuel in Kenyan households is a cause for concern, as it exposes a significant portion of the population to harmful pollutants. According to the Kenya household cooking sector study done by the Ministry of Energy and Petroleum (2019) findings, 75% of all Kenyan households rely on wood fuel for cooking, while in rural areas, this number climbs even higher to 93.2%. The Kenya ceramic jiko (KCJ), as shown below in Figure 7 is the most prominent charcoal stove in Kenya with an estimated 4.2 million households (33.8%) reporting owning at least one. 10.3% of households in Kenya, approximately 1.3 million, use a type of charcoal cook stove as their primary cook stove.

In this study, an improved version of the charcoal stove - Jikokoa manufactured by BURN, is used which consumes less charcoal and emits less C02 as compared to the KCJ. The Jikokoa is shown in Figure 7-b

a) Kenya Ceramic Jiko (KCJ)

b) Improved cookstove

Figure 7: Charcoal cookstoves used in Kenya

Data on weekly charcoal expenditure collected from households indicates that the annual market value of charcoal consumed by the residential sector alone is KES 68 billion (Ministry of Energy 2019). This is twice the amount spent on LPG and almost 40% more than what all domestic customers paid to Kenya Power in 2018 (KPLC, 2018.). Only 3 % of households own an electric cooking appliance such as a mixed LPG-electricity stove, electric coil stove, and microwave. Given these statistics, it is important to note the exposure of these households to harmful gas and particulate matter released from the combustion of biomass and kerosene that leads to household air pollution (HAP). HAP has emerged as one of the largest health risk factors for mortality in Kenya, causing at least 23,000 deaths each year (Nation, 2022). A number that surpasses the average number of deaths caused by road accidents in the country. The high mortality rate associated with HAP emphasizes the urgent need for a transition from traditional cooking methods to cleaner and more efficient technologies and fuels.

The study underscores the importance of adopting clean cooking practices as a crucial step towards improving public health and mitigating the adverse effects of unclean cooking on both the environment and the well-being of the Kenyan population. The report contributes to the Kenya Cooking Transition Strategy (KCTS), led by the Ministry of Energy, and involves a consortium of development partners which include MECS, and UK PACT. The strategy is aimed at developing pathways to achieve Universal Access to Clean Cooking by 2028 and contribute to Kenya's Nationally Determined Contributions (NDCs). A Kenyan National eCooking Study and Strategy (KNeCS) is also currently being developed which will feed into the overarching strategy of KCTS. KNeCS is focused on scaling up the adoption of energy-efficient eCooking technologies that will minimize the environmental and health impact of using biomass fuels for cooking.

This report presents the findings of a study that assessed the viability of sustainable cooking technologies in Kenya, with a focus on understanding cultural cooking patterns and preferences, energy efficiency, cost-effectiveness, and overall user experience. The key research question used during this study was:

- *How do modern energy-efficient electric appliances compare with other popular cooking devices across the most common dish types cooked by Kenyan households?*

Food, Cooking Fuels, and Choice of Technologies in Kenya

Food Culture and Choices

To better understand the food culture and choices in Kenya, Table 3 below is a table of common foods, their cooking process, and typical cooking duration. The meals represented in the table are the foods that were selected to be prepared in this study's-controlled cooking tests. The 7 dishes are a representation of the specific categories of food dishes on the Kenyan menu, as defined by the cooking processes involved in their preparation. For example, we picked beans as a 'heavy food' that requires boiling for a long time and then frying with a sauce. Other heavy foods include githeri or matumbo. We also picked beef which is a 'common meaty stew' that requires boiling the meat and then frying it in a sauce as well. Other meaty stews cooked similarly include chicken stew, goat stew, or any other animal protein. Though beans and beef are prepared in the same manner, we included both as they are different protein categories, and we also couldn't choose which best represents the 'heavy foods' category. We also choose common starchy staple foods like ugali and rice that are prepared by first boiling water and then adding in the flour and rice respectively. Rice and Ugali are interchangeably eaten in Kenyan households so it was also hard to pick which one best represents the category. Chapati, cooked on a flat, circular cast iron or aluminum plate, is a starchy staple as well. We picked spinach as a vegetable food, which is commonly taken with Ugali or as a side garnish for stews such as bean or beef stew. Finally, we chose chips to represent deep-fried foods in the tests.

Many popular dishes in Kenya can be prepared through either boiling, frying, simmering, deep frying, roasting, or a combination of these techniques. In Kenya, boiling stands as a prevalent and essential cooking technique, involving the addition of water to food and heating it to the boiling point. This method finds extensive use in preparing various dishes such as githeri, rice, chips, and beans, which form an integral part of Kenyan cuisine. The daily meals of Kenyans often include combinations like ugali with sukuma wiki and meat, or rice stewed with meat or beans, creating sumptuous and flavorful meals.

Table 3:A table of the foods cooked during the study.

Representative Food	Food Category	Cooking Process	Duration of Cooking (in minutes		Similar Foods
			Preparation	Cooking	
Beans	Heavy Foods	Boiling the beans for an hour then frying in a sauce	10	120	Githeri, Njahi, Ndengu,
Beef	Heavy (Animal) Foods	Boiling for an 30-60 mins then frying in a sauce	10	90	Chicken, Goat, Matumbo
Rice	Starch	Mostly Boiled.	5	30	Millet
		For Pilau or Vegetable Rice, this will be different as frying of onions occurs first.	10	90	
Ugali	Starch	Boiling then stirring and mixing in flour	5	30	Porridge
Chapati	Starch	Pan-fried over heat.	30	30	Naan
Chips	Starch	Deep-frying	20	30	Mandazi, Samosa
Sukuma Wiki	Vegetable	Sauteing	15	15	Cabbage, Sukuma Wiki

Stewing, another popular cooking method, showcases the art of combining diverse ingredients in a single pot, allowing them to cook together and develop rich flavours. As the sauce simmers and thickens, different elements are added at various stages, culminating in a blend of tastes and textures. The process entails a thoughtful mixture of techniques. For example, preparing bean stew in the Kenyan context involves boiling the beans to perfection, sautéing basic ingredients such as onions, tomatoes, and green peppers, and finally simmering all the ingredients together, enhancing the dish's savory taste. Meat and beans are considered in the same food category as energy intensive as they must be boiled first before being stewed.

It is worth noting that Kenya boasts of a rich diversity with no singular culture defining its identity. The nation comprises approximately 47 distinct ethnic groups, each cherishing its unique traditions. Consequently, there is no single dish that represents the entirety of Kenya.

The heart of Kenyan cuisine lies in its utilization of fresh, locally sourced, and affordable ingredients. The region's abundant produce, including kale, spinach, cabbage, tomatoes, beans, potatoes, avocados, and various leafy greens, takes center stage in daily culinary creations. The cooking culture involves a lot of boiling especially for grains such as beans and githeri – a combination of maize and beans – which are staple Kenyan household meals.

As for animal proteins, goat meat, beef, and chicken are the preferred choices, with goat meat occupying a special place in the culinary hierarchy. Along the coastal regions, a delectable array of seafood like crab, crayfish, lobster, prawns, kingfish, parrotfish, tuna, sailfish, and marlin grace the tables in abundance, celebrating the coastal culinary heritage. Staple starches in Kenya encompass a range of grains such as cornmeal, rice, wheat, maize, and millet, alongside their respective flours. These form the foundation of many dishes, adding a wholesome and satisfying element to the meals.

Embracing the diverse bounty of nature, Kenyan cuisine showcases a delightful fusion of flavors, honoring its cultural roots while incorporating local preferences and culinary techniques. This harmonious blend of fresh produce, rich animal proteins, and staple starches defines the tapestry of cuisine that Kenyans cherish and enjoy every day.

Cooking Fuels and Technologies

The Kenya household cooking sector study (MoE, 2019) shows that approximately 90% of the rural population and roughly 75% of all Kenyan households continue to rely on fuelwood or charcoal for cooking purposes. On the other hand, a mere 20% of households use LPG as their primary cooking technology. The same study revealed that woodstoves dominate as the primary cooking technology in Kenya, accounting for 65% of households nationwide. This trend is particularly pronounced in rural and off-grid areas, where wood stoves are used by 86% and 88% of households, respectively. However, urban households and those with access to the grid display more diverse choices. LPG stoves are the most common (46%) primary cooking device in urban areas, while wood stoves (21%), charcoal (17%), and kerosene (16%) also have a significant presence. However, only 17% of urban and 7% of rural households consider charcoal stoves as their primary cooking option. This mix of cooking technologies reflects the varied urban and rural characteristics of households with grid access.

Fuel stacking, which refers to the practice of utilizing multiple cooking devices and fuels to meet household energy requirements effectively, allows households to select their preferred fuels and cookstoves majorly based on affordability. Despite being a prevalent phenomenon, it is often overlooked in surveys that focus solely on the "primary" stove or fuel used. When households adopt new energy solutions, existing options are seldom replaced entirely. Instead, the norm is to witness the integration of new technologies alongside existing ones. This could entail using multiple technologies to prepare a single meal, employing different devices for various meals throughout the day, or exploring other combinations to optimize cooking practices. The concept of stacking sheds light on the diverse and adaptable nature of household energy consumption in response to varying needs and preferences.

About one in every two (49%) households in Kenya use only one type of stove option (specific category of stoves) while 36% use two types of stoves. The remaining 15% have three or more options (MoE 2019). According to the report, there's no significant difference in the stacking behaviour between rural and urban households. In both setups, the percentage of households that own at least 2 cookstoves is more than 80%. The table below gives a further breakdown of the fuel stacking identified during the study.

Table 4: Percentages of primary and secondary pairings of cooking options nationwide

		A	B	C	D	E	F	G	H
	Secondary stove / Primary stove	**No 2nd stove**	**LPG**	**Electric**	**Kerosene**	**Charcoal**	**Wood**	**Other**	**Total**
1	LPG	6.6%	1.3%	0.3%	2.2%	6.5%	2.0%	0.1%	19.00%
2	Electric	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.20%
3	Kerosene	3.3%	0.2%	0.0%	0.0%	1.9%	0.2%	0.0%	5.60%
4	Charcoal	4.9%	2.0%	0.0%	1.1%	0.3%	2.0%	0.0%	10.30%
5	Wood	34.5%	5.4%	0.0%	0.8%	22.9%	1.1%	0.0%	64.70%
6	Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.10%
	Total	**49.40%**	**9.00%**	**0.30%**	**4.10%**	**31.60%**	**5.40%**	**0.10%**	**99.90%**

Fuel stacking is even more prevalent with electric appliances, many of which are task-specific. For example, a kettle is very efficient and convenient at boiling water but can't prepare a full dish, as other cooking processes are required. A single household may therefore use a kettle in combination with other cooking fuels to meet its complete cooking needs, or in combination with other electric appliances, or both.

The following subtopics briefly discuss the various fuels available for cooking in Kenya. This list does not exhaust all the fuel types available, but it discusses the ones that were relevant to the tests included in this study.

Charcoal

The use of charcoal for cooking in Kenya is influenced by various factors, including socio-economic determinants, government policies, and the availability of alternative cooking fuels. Charcoal is one of the most important sources of energy in Kenya, especially in urban areas. Kenya's urban centers especially are highly reliant on charcoal to meet the population's energy needs. Charcoal is the primary energy source for 43% of families in Nairobi alone, and 86% of them use it for cooking and boiling water (Gonzalez, 2020). Alternative fuels like briquettes have failed to gain consumer acceptability due to social and economic factors. In households, charcoal is mostly used for boiling hard foods like beans, meat, and githeri.

Figure 8: One of the cooks using the ICS during the study

Kerosene

Kerosene use for cooking is still prevalent in urban low-income areas—1.7 million households in Kenya or 14 percent of the total population cook with kerosene. At least 27.7 percent of these are in urban households and 3.2 percent are in rural areas. (MoE 2019.)

Figure 9: Spinach being cooked on the kerosene stove during the study.

LPG

Kenya has a well-defined LPG distribution supply chain regulated and licensed by EPRA. EPRA provides for various kinds of licenses including import, export, and wholesale of LPG in bulk; transport of LPG in bulk; wholesale of LPG in bulk; and wholesale of LPG in cylinders. As of January 2019, EPRA had issued licenses to 33 importers, 41 storage facility operators, 91 transporters, and 46 export and wholesale dealers (EPRA, 2019). 3.7 million households or 30% of the population (54% urban and 18% rural) use LPG and 2.4 million households, 19% of households nationwide, consider it their primary fuel. (MoE & CCAK, 2019).

Ethanol

Ethanol as a liquid cooking fuel has historically had a low market share, with most households preferring LPG or kerosene, due to the technologies for these energy sources being more established. Consequently, (Dalberg, 2018) notes that bioethanol is the least appreciated fuel in most developed nations. However, after the implementation of the Kenya Ethanol Cooking Fuel Masterplan by IKI, there has been increased uptake, with 950,000 households showing uptake of ethanol-based fuel solutions such as those offered by Koko (Osiolo et al., 2023). With ethanol use offering a low emissions pathway that also reduces in-house air pollution, the sector is continually growing.

Figure 10: Koko ethanol stove

Electricity

Though electricity access has risen sharply in the last decade to 76% in 2021(Kenya Power and Lighting Company, 2022), the use of electricity as a source of fuel for cooking has not gained wide acceptance in Kenya. MoE & CCAK (2019) reported that only 3% of households own an electric cooking appliance such as a mixed LPG-electricity stove, electric coil stove, and microwave. The report highlighted the high upfront cost of electric cooking devices such as the mixed LPG-electric stove as a significant barrier to uptake. However, there are a range of much more affordable and energy-efficient appliances now available, such as the electric pressure cooker from VON that retails for KES 12,995, the induction plate from Ramtons retails at KES 8,500 or a rice cooker that retails for KES 6.700. The draft baseline study for the National eCooking Strategy recently reported that when considering a broader range of electric appliances that can be used as part of the cooking process, 24% of Kenyan households own eCooking appliances, the majority of which are kettles, water heaters, and microwaves.

Electric kitchen appliances utilize various technologies and mechanisms to achieve efficient cooking processes and energy savings. The key is often in their direct heat transfer, quick response times, and features that minimize energy consumption. The electrical appliances used in this study are explained further below:

Electric Pressure Cooker

An electric pressure cooker (EPC) is a versatile kitchen appliance that combines the functions of a traditional pressure cooker with modern electronic controls. It consists of a sealed pot with a pressure valve, a heating element, and a control panel. The sealed environment allows for increased pressure, raising the boiling point of water and reducing cooking time. The cooking process involves placing ingredients inside the sealed pot along with the desired liquid (water, broth, etc.) The lid is securely closed, and the pressure cooker is set to the desired cooking time and pressure level using the control panel. The heating element raises the temperature and pressure inside the pot, cooking the food faster than conventional methods. Once cooking is complete, the pressure is released manually or through a natural release mechanism.

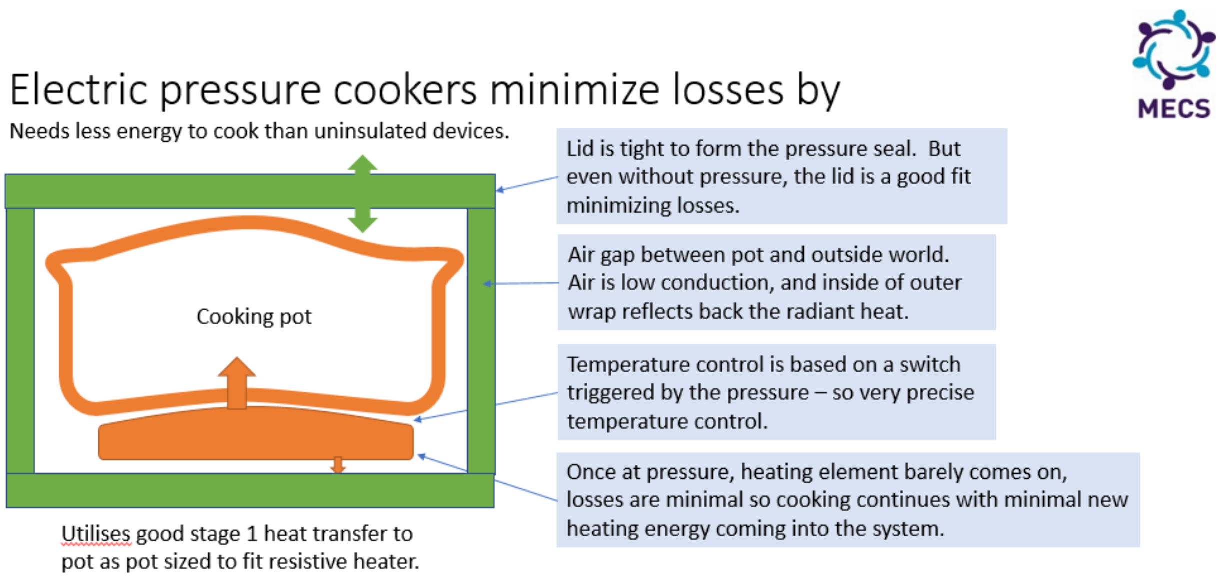

Figure 11: Internal working of an EPC (Batchelor, 2023)

Infrared Cooker:

An infrared cooker uses infrared radiation to directly heat cookware, providing precise and efficient cooking. It typically consists of a flat, smooth surface with infrared heating elements beneath. The infrared cooker is turned on, and the heating elements produce infrared radiation. Cookware placed on the surface absorbs the radiation, and the heat is transferred directly to the food. Temperature controls, by use of a thermostat, allow users to adjust the heat level for different cooking tasks. It saves energy by employing the following mechanisms.

- Direct Heating: Infrared cookers heat cookware directly, minimizing heat loss to the surrounding environment.
- Rapid Heating and Cooling: Quick response times to changes in temperature contribute to energy efficiency.
- Even Heat Distribution: Uniform heating reduces the need for prolonged cooking times.

However, an induction cooker radiates heat, leading to heat loss, to its immediate surroundings from the sides of the pot which can be about 400W (Batchelor, 2023).

Induction Cooker:

An induction cooker uses electromagnetic induction to heat cookware directly. It consists of a flat surface with an induction coil beneath and a control panel. When turned on, an electric current passes through the induction coil, creating an electromagnetic field. When compatible cookware is placed on the surface, it induces a current, generating heat directly in the cookware. It saves energy in the following ways:

- Direct Heat Transfer: Induction cookers heat cookware directly, minimizing energy loss to the surrounding environment.
- Precise Temperature Control: Users can quickly adjust temperatures, reducing the risk of overheating and energy waste.

- Auto Shut-off: Some models have sensors to detect cookware presence, automatically turning off when no cookware is detected, saving energy.

Similar to infrared cookers, the induction cooker loses heat when cooking due to the lack of insulation. When simmering, the induction will compensate for these losses by employing a thermostat to allow for rapid heat level adjustment.

Hot Plate

A hot plate is a portable electric cooking appliance with one or more heating elements. It is often a compact, standalone unit. The cooking process involves plugging the hot plate into a power source to turn on the heating element. The heating element may take a while to heat before it achieves the desired heat levels, and the heat is controlled by the thermostat. Cooking with a pot that is smaller than the diameter of the heating element leads to heat loss during cooking, and this could also pose a safety risk.

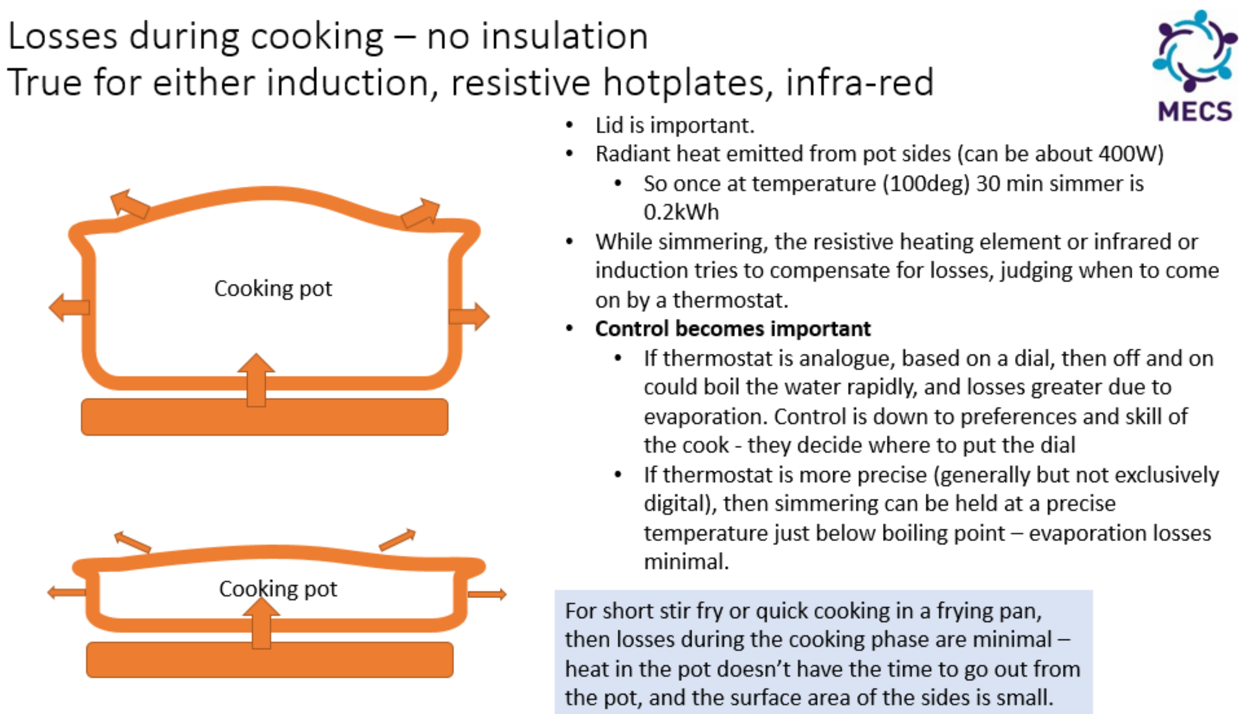

Figure 12: Losses for cookstoves with no insulation (Batchelor, 2023)

Air Fryer

An air fryer is a countertop appliance that cooks by circulating hot air around the food using convection. It often features a basket or tray and a heating element. The cooking process involves placing the food in the basket or on the tray and turning it on. The air fryer's heating element produces hot air, and a fan circulates the air around the food. The circulating hot air crisps and cooks the food, providing a similar texture to deep frying.

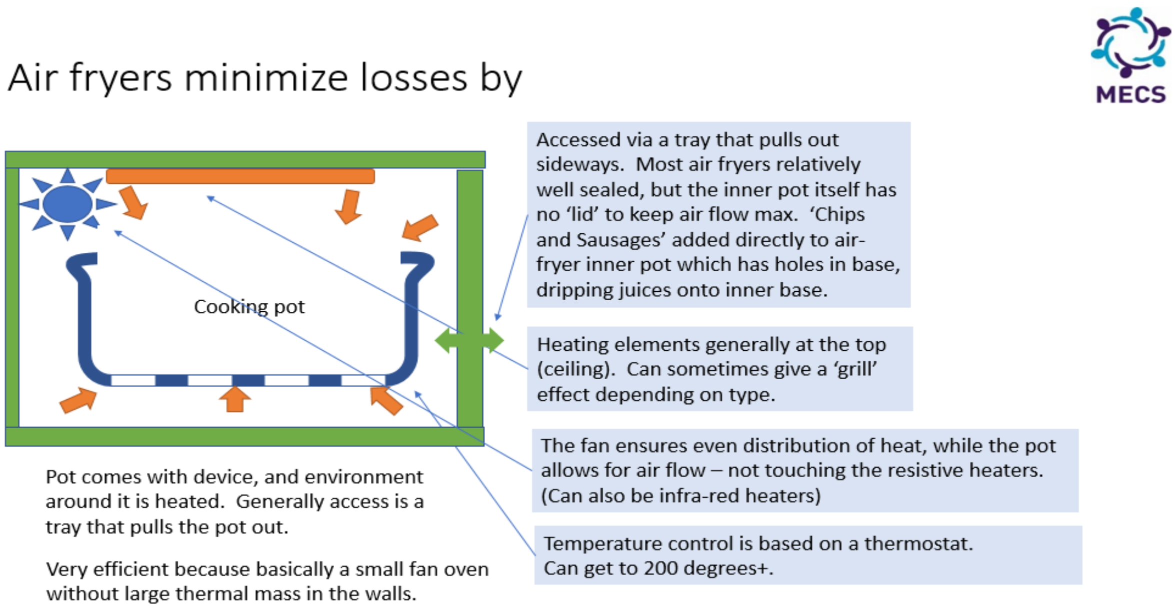

Figure 13: How air fryers minimize loss (Batchelor, 2023)

Rice Cooker

A rice cooker is an automated kitchen appliance designed for cooking rice but can cook other meals like spinach when the lid is off. It typically consists of a removable inner pot, a heating element, and a thermostat. When switched on, the heating element raises the temperature of the pot bringing the contents to a boil. The thermostat then detects the temperature change and switches to a low heat setting to simmer the rice. When the rice is cooked, the thermostat may switch to a "keep warm" setting.

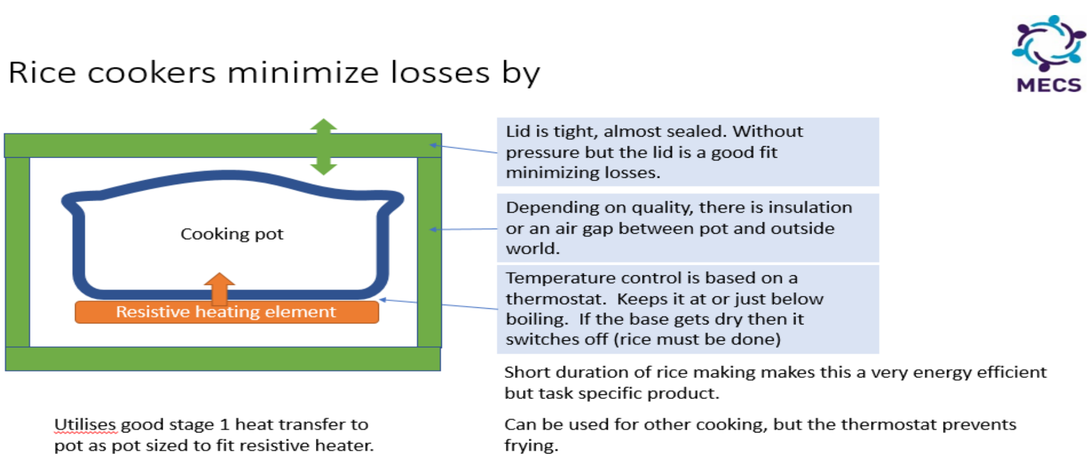

Figure 14: How rice cookers minimize losses (Batchelor, 2023)

Methodology

Figure 15: Cooking during the CCTs

Controlled cooking tests (CCTs) are a methodology designed to evaluate the performance of various cooking appliances across selected meal categories to measure the energy consumed and time taken to cook a specific dish from each category. This was the methodology used for this study. CCTs can also be used to determine the econometrics around cooking fuels, the cooking experience, and the taste of food across appliances (Leary, 2023). CCTs are meant to reflect the actual day-to-day cooking of specific dishes in households. Below is a table of the matrix showing the meals that were prepared, which appliances were used, the method of cooking, and a summation of the tests done. The meals were chosen based on the commonly cooked foods in Kenyan households that highlight the different methods used to cook the main food group categories. Beans, a long-boiling food represented cereals, beef–boiled then stewed beans represented proteins, spinach represented vegetables and rice, ugali, chips, and chapati represented the commonly cooked starch meals. The appliances were selected based on the commonly used cookstoves (both electrical and non-electrical) found in households and electrical appliances that are gaining popularity like the EPC and the air fryer. The meals chosen were further categorized into various cooking processes. The cooking processes chosen were boiling and frying. Beans, beef, and rice were boiled whereby beef and beans were then stewed. Spinach as the vegetable of choice was also stewed. On the other hand, chapati and chips were fried in that chapati was pan-fried while potatoes were deep fried.

Table 5: Matrix of meals prepared, appliances used, and method of cooking used for the CCTs.

Foods		Beans	Beef stew	Chapati	Potatoes (Chips)	Rice	Vegetable
Cooking Methods		Stewed (with boiling split measurement)	Stewed	Pan fried	Deep fried	Boiled	Stewed
APPLIANCES	EPC	☑	☑	☐	☐	☑	☑
	Induction cooker	☑	☐	☑	☑	☑	☑
	Rice Cooker	☑	☐	☐	☐	☑	☑
	Air frier	☐	☐	☐	☑	☐	☐
	Infrared	☑	☐	☑	☑	☑	☑
	Hot plate	☑	☐	☑	☑	☑	☑
	Gas cooker - LPG	☑	☑	☑	☑	☑	☑
	Charcoal	☑	☑	☑	☑	☑	☑
	Ethanol	☑	☐	☑	☑	☑	☑
	Kerosene	☑	☐	☑	☑	☑	☑
	TOTAL	9	3	7	8	9	9
	TOTAL	45					

Carrying out CCTs involves the below-outlined steps:

i. Preparation of ingredients. This is done in advance before the actual cooking begins.
ii. Selection of measuring equipment.
iii. Preparation of the cooking fuels and selection of cooking pots.

iv. Measurement of weight of food, energy measurements of cooking fuel, and time taken at the beginning and end of the cooking process Rating of cooking experience and taste of food after cooking.

v. Data Analysis

The CCTs were carried out at the Kenya Power *Pika na Power* kitchen. They were designed to determine the energy and time consumed across all 10 appliances for the 7 specific meals. The cooks engaged in cooking practices that reflected the normal cooking routines of typical Kenyan families. Each dish was prepared with a similar recipe and procedure across all the devices it was prepared on. Each appliance prepared two portions of the same meal. Below is a table of the appliances used for this study, and their upfront costs.

Table 6: A table of the appliances used during the CCTs Source: Strathmore University

Appliance	**Brand**	**Upfront Cost**
EPC	Von	KES 12,995
	Ramtons	KES 12,800
	Tefal	KES 12,600
Induction Cooker	Local Retailer	KES 7,000
Rice Cooker	Von	KES 5095
Air Fryer	Kenwood	KES 18,995
	Tefal	KES 16,000
Infrared Cooker	Sokany	KES 6,908
Hot Plate	Ramtons	KES 6,000
LPG Stove (Meko)	Total - 6Kgs	
	Gas Refill	KES 1380
	Cylinder (Without gas)	KES 3680
Improved Charcoal Stove	Burn	KES 5,000
Kerosene Stove	Unknown	KES 740
Ethanol	Koko Networks	
	Stove+2.3 Litres Ethanol Fuel	KES 2,000
	Fuel Refill	KES 175

The following assumptions were made:

1. The same appliance type with different brands has similar characteristics.
2. Common recipes in Kenya were used in carrying out the cooking tests (The data may vary with different cooking styles).

3. The rice cooker is forced into cooking mode when cooking. We override a rice cooker to keep it in cooking mode.

Table 6:Parameters and Tools used in the CCTs to weigh fuel consumption and time.

Parameter	**Tools used for Measurement**
Electricity consumption(kWh)	Plug-in energy meter with 0.001 resolution
Time taken to prepare Meals(seconds)	Digital Watch
Fuels Used from non-electric appliances(grams)	50kg Weighing Scale with 5g resolution

The following conversions were used for ethanol and kerosene:

- 1 litre of ethanol is equivalent to 0.78kgs of the same.
- 1 litre of kerosene is equivalent to 0.9kgs of the same.

Standardized recipes for each meal were prepared and followed by all cooks (see appendix). Eight cooks participated in the dish preparation, cooking, and recording of data. The above-mentioned meals were each cooked at least twice on each appliance and where the first two results yielded significantly divergent outcomes, with more than 15% difference in time taken to cook and energy consumption, a third test was done. The cooks recorded the data manually for all cooking events then the data was transferred into a digital tool for ease of analysis.

The ratings of various cooks on the taste of the meal cooked and the ease of use of the appliances used in this test were also recorded. As a limitation of the study, the cooks tasted and rated the meals after they were cooked. After the cooking for each meal was done, the meal was placed alongside each other, and all the cooks tasted and gave a rating of the taste of the meal. The cooks further gave a rating on the ease of use of the appliance they used to cook the meal. A rating scale of zero to five was used whereby five represented the highest score such that the appliance was easiest to use, and the meal tasted great. On the other hand, zero represented the lowest score on taste and use of appliances.

Table 7: Assumptions and Energy Conversion

Assumption	**Units**	**Source**
The energy content of charcoal (MJ)/kg	31	Engineeringtoolbox.com
LPG energy content (MJ)/kg	46.1	Engineeringtoolbox.com
Energy Content of Ethanol (MJ)/kg	27	Engineeringtoolbox.com
Energy Content of Kerosene (MJ)/kg	43.1	Engineeringtoolbox.com
MJ conversion to kWh	0.2778	Engineeringtoolbox.com
kWh conversion to MJ	3.6	Engineeringtoolbox.com
The below costs were considered during the time of testing.		
Cost of 1 kg of Charcoal	70 KES	Price in Rongai (August 2023)
Cost of 1 kg LPG gas	230 KES	Total Energies
Cost of 1 kg Ethanol	77.83 KES	KOKO FUEL.COM
Cost of 1 kg Kerosene	203.06 KES	EPRA(OCTOBER;2023)
1 kWh of electricity Cost Domestic Lifeline customers using 0-30kWh/month (units per month).	22.84 KES (As of October 2023)	stimatracker.com
1 kWh of electricity cost Domestic Ordinary customers using 31-100kWh/month (units per month)	27.78 KES (As of October 2023)	stimatracker.com

For analysis, the Domestic Lifeline customer, who is categorized by the Kenyan regulator (EPRA) to be a customer consuming or having an energy limit of 0-30kWh/month (units per month) shall be referenced as Band 1. In addition, the Domestic Ordinary 1 customer who is categorized to be consuming or having an energy limit of 31-100kWh/month (units per month) shall be referenced as Band 2. These two tariff bands represent the average consumption base of Kenya which is about

30kWh/month. According to the Retail Electricity tariff review released by EPRA in 2023 (EPRA, 2023), approximately 6.4 million customers are in the domestic lifeline category. Band 1 will be considered as the lowest tariff while Band 2 will be considered as the highest tariff in this report.

The energy consumption was calculated as the total energy (fuel) consumed by the appliance to cook each meal per test to the desired readiness level. For the non-electrical appliances, this value was obtained by measuring the weight of the cooking appliance before adding fuel and after adding fuel for the first time, and any fuel that was added subsequently while cooking was also measured and recorded. The weight of the cooked food was also considered. For the electrical appliances, an energy meter was recorded for the appliances and readings were taken at different intervals of the cooking process.

The time was recorded from when the pot was ignited or switched on to when it was turned off. The energy cost analysis took into consideration the energy prices at different locations and times of the year. The energy cost is a product of the energy consumed and the cost of that fuel.

Results

The sections below present the findings of the controlled cooking tests across devices for the different types of dishes cooked. Eight cooks participated in the dish preparation, cooking, and recording of data.

Figure 16: Recording of test results during the testing.

Energy Consumption, Time Taken, and Cost Comparisons for the Meals

The table below presents a snapshot comparative analysis of the 10 cooking devices across three parameters — energy efficiency, cost, and cooking time — for the five different foods: beans, rice, spinach, chapati, and chips. Ugali and beef have been excluded from the analysis due to their limited testing. Ugali was cooked once in the EPC while beef was cooked on three appliances only.

Table 7: A snapshot glance at the energy, time, and cost analysis of the 5 meals.

Energy (kWh)	Beans	Rice	Spinach	Chapati	Chips
Infrared	2.84	0.28	0.21	0.04	0.16
Induction	0.82	0.20	0.22	0.03	0.13
Air Fryer					0.27
EPC	0.32	0.12	0.18		
Rice Cooker	2.90	0.27	0.18		
Hot Plate	3.55	0.20	0.25	0.05	0.23
Gas LPG	2.16	0.29	0.22	2.06	1.12
Kerosene	3.11	0.42	0.30	0.27	0.33
Charcoal	3.94	0.60	0.54	0.23	3.26
Ethanol	4.46	0.43	0.30	0.23	1.88

Legend
Inefficient
.
.
Efficient

Cost (KSh)	Beans	Rice	Spinach	Chapati	Chips
Infrared	34.7	3.4	2.6	0.5	1.9
Induction	10.0	2.4	2.7	0.4	1.6
Air Fryer					3.3
EPC	3.9	1.5	2.2		
Rice Cooker	35.4	3.3	2.2		
Hot Plate	41.4	2.4	3.1	0.6	2.8
Gas LPG	29.1	3.9	3.0	3.4	14.0
Kerosene	44.1	5.9	4.2	3.8	30.8
Charcoal	32.0	4.9	4.4	1.9	26.5
Ethanol	46.3	4.4	3.1	2.3	23.0

Legend
Expensive
..
..
Cheap

Time (mins)	Beans	Rice	Spinach	Chapati	Chips
Infrared	158	22	13	4	10
Induction	176	27	11	3	7
Air Fryer					14
EPC	62	17	14		
Rice Cooker	167	22	11		
Hot Plate	240	16	14	5	8
Gas LPG	178	20	10	4	11
Kerosene	166	23	12	5	16
Charcoal	186	22	18	2	6
Ethanol	181	20	10	9	12

Legend
Slow
..
...
.
Quick

Beans, rice, and spinach were cooked across nine appliances except for the air fryer. For all three dishes, the EPC consumed the least amount of energy with the lowest being 0.12kWh when cooking rice. When cooking beans, the EPC consumed four times less than the average energy between the ethanol stove and ICS. The induction cooker used for this study proved to be energy efficient across all food types, with particularly notable efficiency in cooking chips and chapati.

When cooking chips, the air fryer proved to be more advantageous than the traditional charcoal fuel consuming only 0.27 kWh compared to the 3.26 kWh of charcoal.

When considering the cost, which was calculated per cooking session, the EPC showed a strong advantage, being the least expensive option for cooking rice, spinach, and beans. The induction cooker was the most cost-effective when cooking chapati and chips as the EPC was not tested for these two meals This reflects a lower operating cost per use, making them a cost-effective choice in the long term. Traditional cooking fuels, charcoal, and kerosene were generally the costliest across most meals. Amongst the electrical appliances, the hotplate had the highest operating cost per use when cooking beans but proved to be amongst the cheapest appliances when cooking chapati.

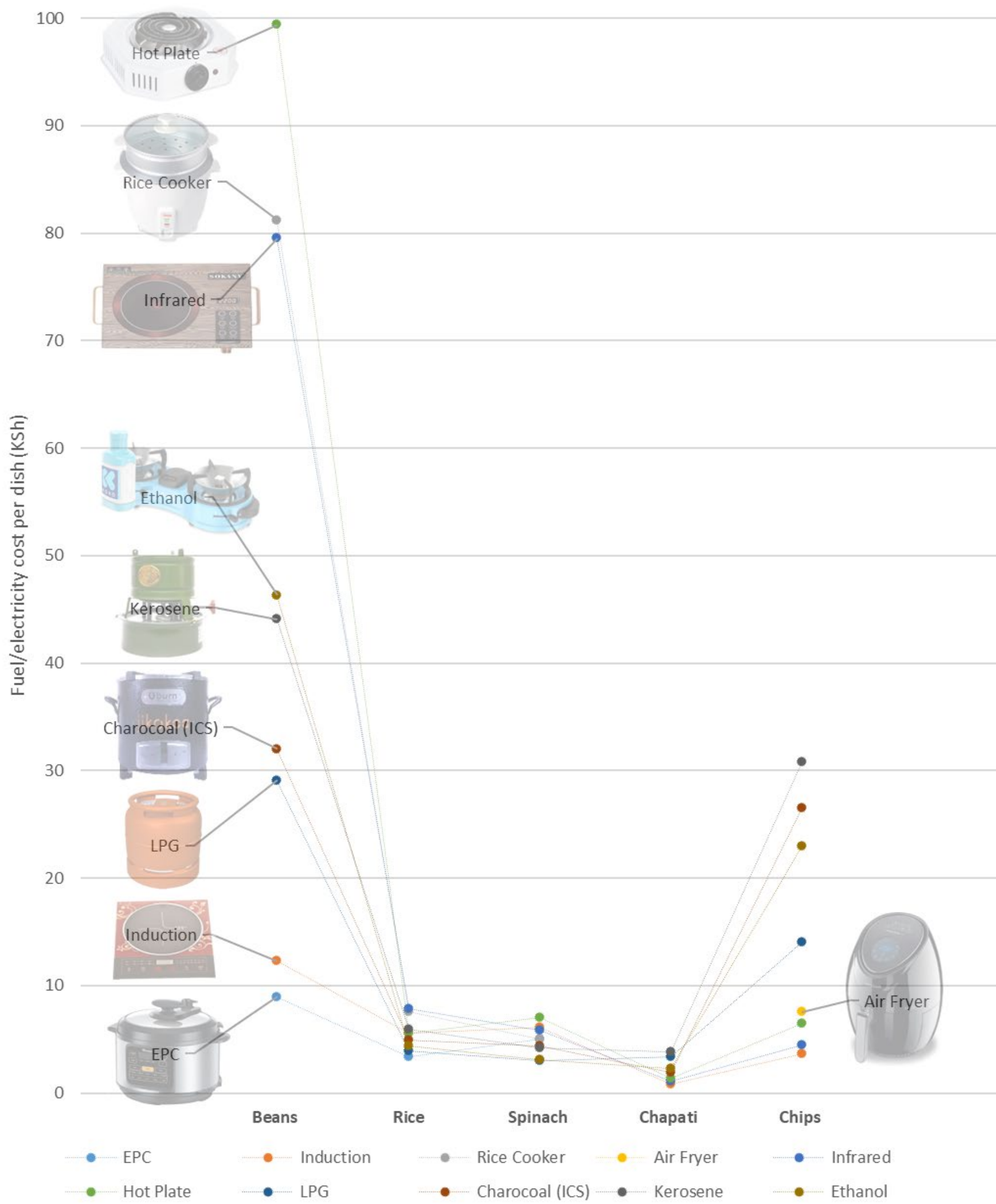

Figure 17: Comparison of the cost of cooking each type of dish with each cooking device.

The EPC led to time efficiency in cooking foods that required boiling and then stewing, like beans. For example, cooking beans on a hot plate took three hours, while the EPC cooked in an hour, offering considerable timesaving. The induction cooker was followed closely as a time-saving electrical appliance across all the dishes. The ICS took the least amount of time across all appliances, slightly faster than the induction cooker. Given that the ICS is designed to optimize combustion, the cook stove can supply a steady and concentrated heat source which can lead to faster cooking times. Charcoal has a high energy density and when burned in a cooker designed to reduce fuel consumption by more than 50%, it burns efficiently.

Figure 18: Cooks display one of the EPCs used in the tests.

Figure 19 shows a negative correlation between the expected monthly running cost and the appliance's upfront cost. Appliances that have higher purchase prices tend to have lower running costs, resulting in considerable energy cost savings over their lifespan. Although the air fryer has the highest upfront cost and one of the lowest monthly running expenses, this is based on a particular dish type due to its limited versatility. The air fryer's expenses are only equivalent to those of the EPC, which has a cheaper upfront cost and somewhat lower running costs than the others, resulting in substantial savings over time.

Its efficiency is a byproduct of merging pressure cooking with electric power, automated control, and insulation, resulting in faster cooking periods and lower energy use. The induction cooker and the infrared cooker have the same initial cost and are significantly less expensive than the EPC;

however, the induction cooker has a lower operational cost since it is more energy-efficient than the infrared.

The LPG and rice cookers likewise fall below the trend line, indicating that their monthly operating costs are quite modest in comparison to their starting prices. Although the rice cooker is especially designed to cook rice, it can also prepare other boiled foods. It had a comparable energy consumption for rice or sukuma wiki, but when cooked for beans, it was significantly less.

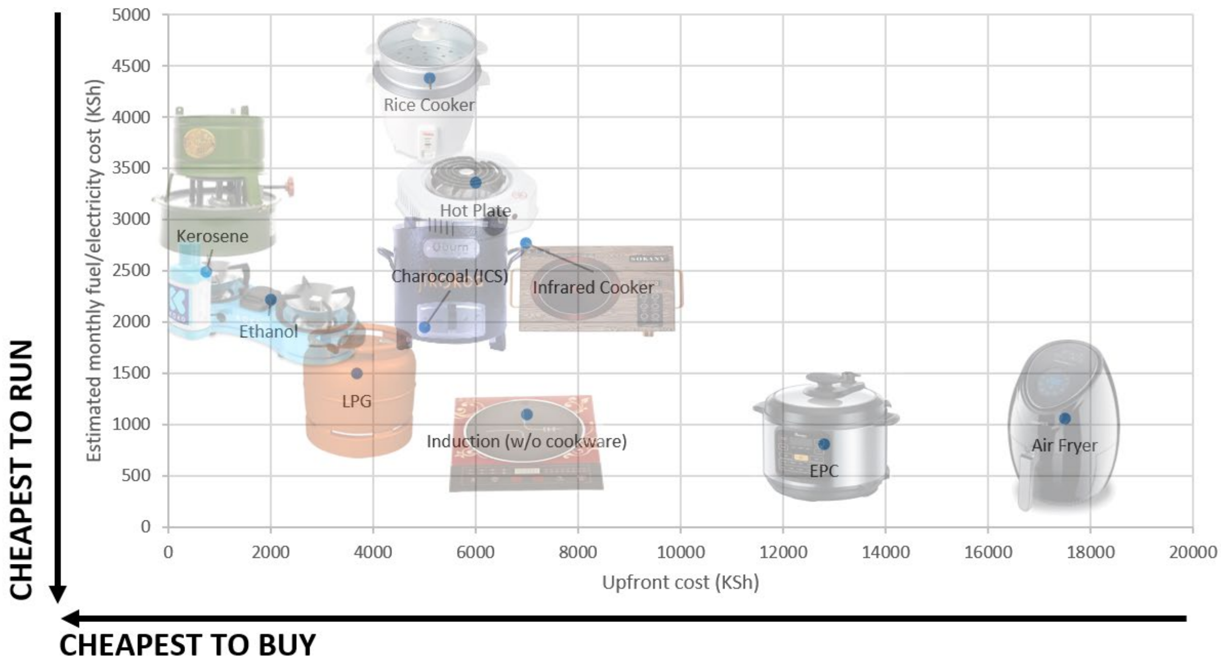

Figure 19: Comparison of upfront and estimated ongoing costs for each cooking device. Ongoing cost estimated by modeling a typical weekly menu consisting of 5 of each dish type. For appliances unable to cook all dish types (rice cooker, EPC, air fryer)

Figure 20 below compares the estimated payback periods of each electric appliance, demonstrating that the induction stove and EPC have the shortest payback period. However, it should be noted that the initial cost of the induction stove does not include appropriate cookware, and neither the EPC nor the air fryer can cook all the meals on the menu, implying that the payback times for both appliances may be substantially longer. The anticipated monthly cost of cooking with the rice cooker, infrared burner, or hot plate was greater than the baseline stack (LPG, charcoal, and kerosene), hence the equipment provided no cost savings.

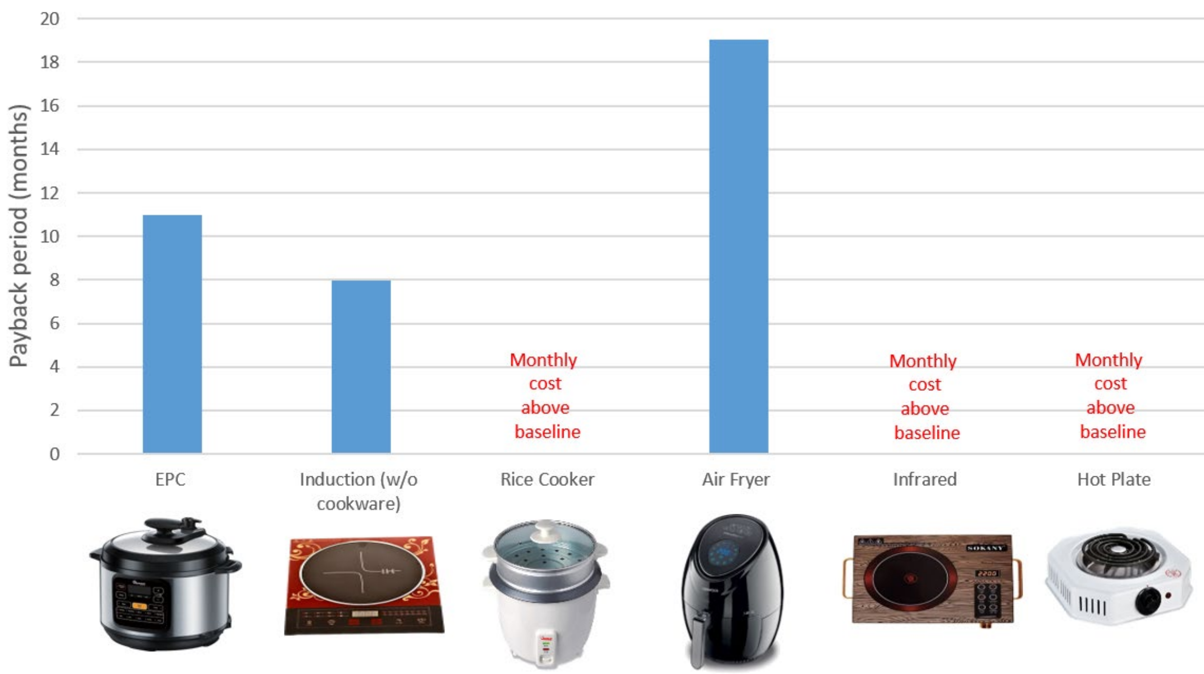

Figure 20: Estimated payback period for each of the eCooking appliances based upon a baseline fuel stack of LPG, charcoal, and kerosene (in equal parts).

Below is the individual breakdown analysis of the meals:

Beans:

Beans are meant to be cooked in two phases: the boiling and sauté phases. For this test, the beans were soaked for 6 hours to soften before being cooked. Soaking dried or hard cereals like beans can reduce boiling time by half (MECS 2019). For beans, it is recommended to soak them until the wrinkles disappear or for several hours.

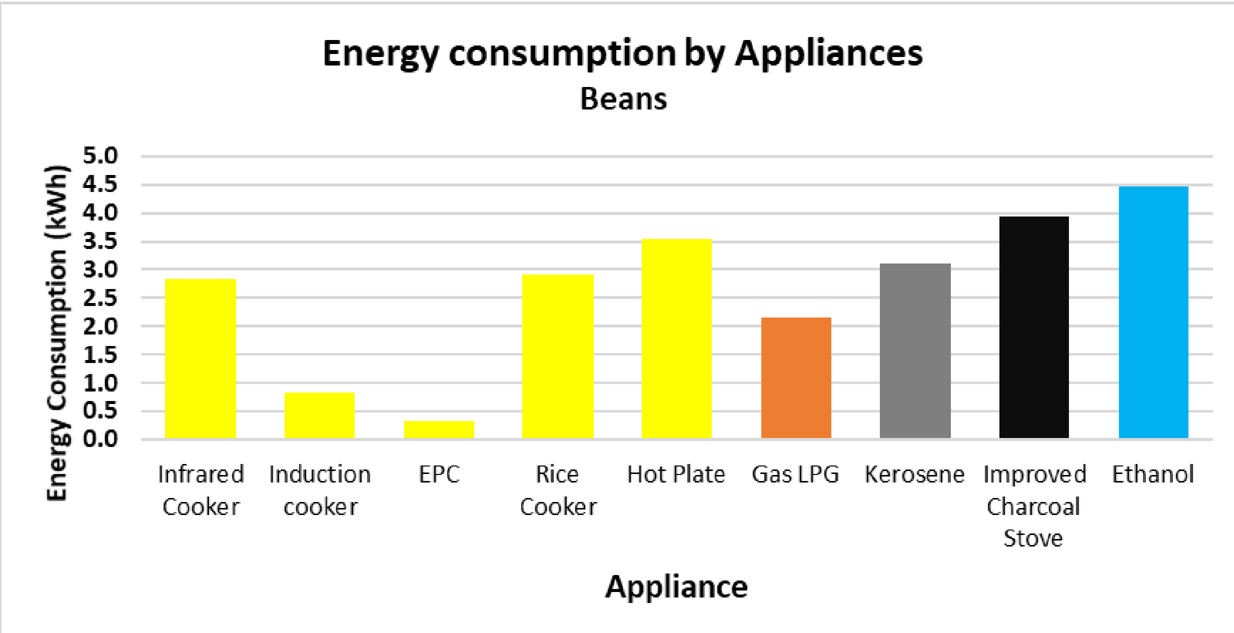

Figure 21: Energy Consumed to cook beans across all appliances.

Figure 21 shows the EPC, and the induction cooker as the most energy-efficient appliances for cooking beans. The LPG consumed half the energy of the ethanol and ICS cook stove. It can however be seen that there's a substantial difference in energy consumption between the EPC and the induction cooker. During cooking, the mode for beans was used on the EPC – which is a programmed setting to cook the food at a determined time and pressure setting. Ethanol stands out as the highest energy-consuming fuel requiring over 10 times the energy consumption of the EPC and over 5 times the energy consumption of the induction cooker. The improved charcoal stove (ICS) consumed slightly less energy than the kerosene cook stove.

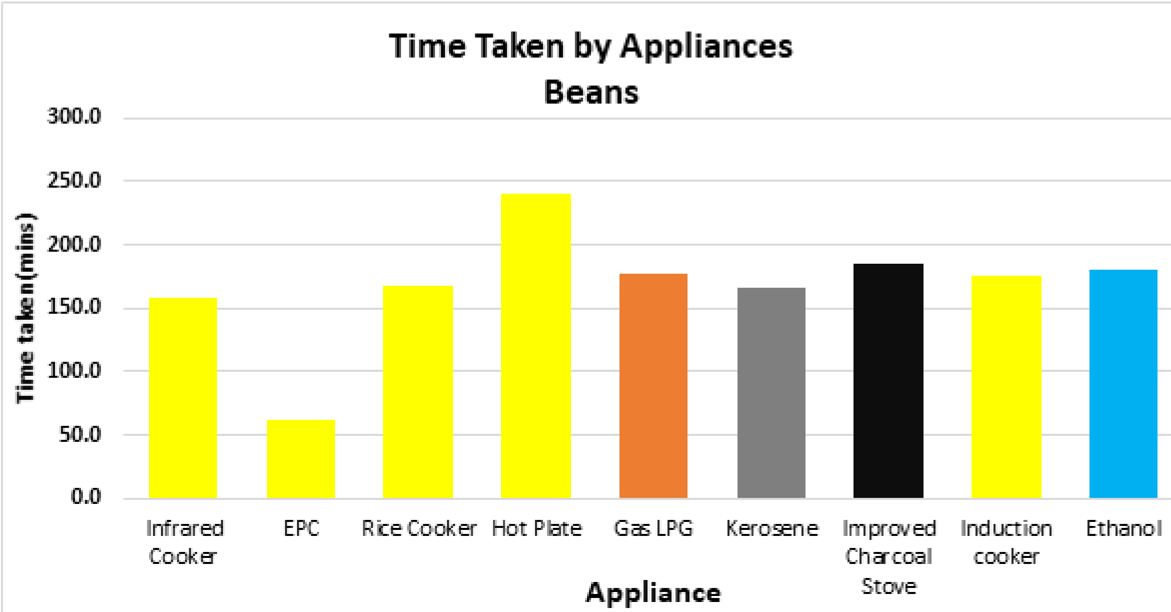

Figure 22: Time taken to cook beans across the appliances.

Figure 22 shows that the EPC demonstrates a shorter cooking time for beans compared to other appliances. This efficiency is likely due to the high-pressure environment within the cooker that speeds up the cooking process by raising the boiling point of water, allowing the beans to cook faster than they would at standard atmospheric pressure. The time taken by the EPC includes both reaching the necessary pressure and releasing it, which, despite being a two-step process, still results in a relatively quick cooking duration. In contrast, the infrared cooker shows a slightly longer cooking time than the EPC. The improved charcoal stove, designed to optimize fuel consumption and heat concentration, does not outperform modern electric appliances. Cooking with ethanol shows a longer cooking time compared to the EPC and infrared cooker but is comparable to the induction cooker. Ethanol burns cleanly and can produce heat quickly, but the total time to cook beans seems to suggest that it's not as effective as some of the other modern cooking methods, possibly due to the stove design or how the heat is transferred to the cooking pot.

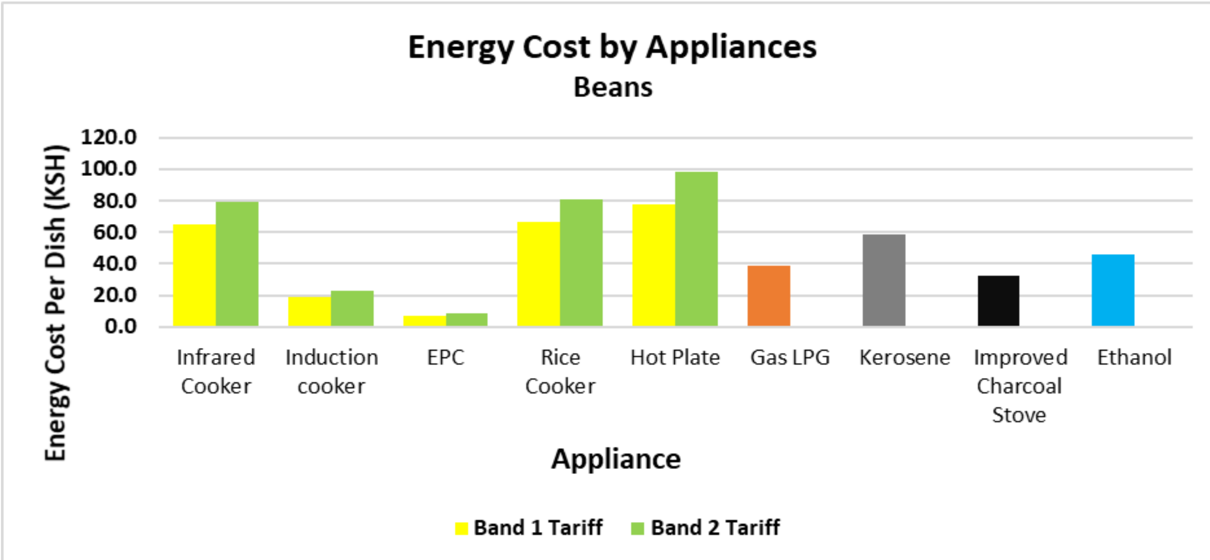

Figure 23: Average cost of fuel for beans across the appliances

The energy cost for cooking beans varies significantly across the different appliances. The EPC is shown to be the most cost-effective for both tariff bands thus proving to be an energy-efficient option, cooking with approx. Ksh 10. The hot plate and rice cooker emerged as the most expensive option for cooking beans. The hotplate's inefficient heat transfer mechanism causes most of the heat produced to be lost in its immediate surroundings. This means that a lot of energy will be required to cook over the extended cooking period of the beans thus resulting in high energy costs. Unlike pressure cookers which build up pressure and then cook in a sealed environment, hot plates and rice cookers may require continuous energy input to maintain required cooking temperatures, leading to higher overall energy use.

Rice:

The rice was boiled across all appliances using a similar methodology. Water and rice were both added at the same time in the respective pots in which the meal was prepared. The rice is then cooked while covered until ready.

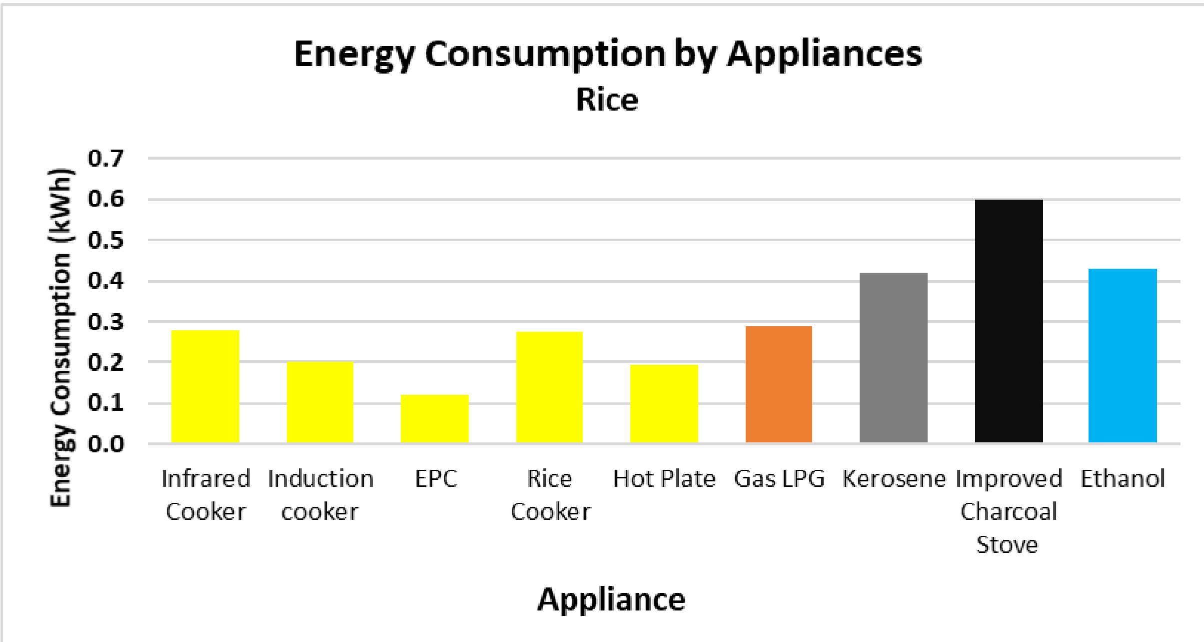

Figure 24: Energy Consumed to cook rice.

The energy consumption graph (Figure 24) for cooking rice with various appliances reveals a spectrum of efficiency levels. The EPC was shown to be the most energy-efficient, due to its pressurized cooking method which speeds up the cooking process. The rice cooker, although specifically designed for cooking rice, consumes marginally more energy compared to the EPC. Generally, though, electrical appliances consume less energy than non-electrical appliances. The improved charcoal stove consumed the most amount of energy to cook rice. The EPC consumed 5 times less energy than the improved charcoal stove, 3.5 times less than kerosene, and 2.4 times less than the energy consumed by the LPG. Both the rice cooker and the EPC received the highest rating in terms of ease of use and taste while cooking rice.

The EPC, and the hot plate display comparable cooking times for rice, which are the shortest on the chart - around 15 minutes. The EPC achieves this through pressurized steam that cooks rice quickly. The hot plate's performance suggests that it can effectively transfer heat during rice cooking, despite typically being associated with slower heat transfer. The rice cooker, designed specifically for cooking rice shows that while it may provide convenience and consistency, it doesn't necessarily offer the quickest cooking time.

The LPG and ethanol stoves prepared the meal in under 20 minutes proving to be time-saving non-electrical appliances for the dish.

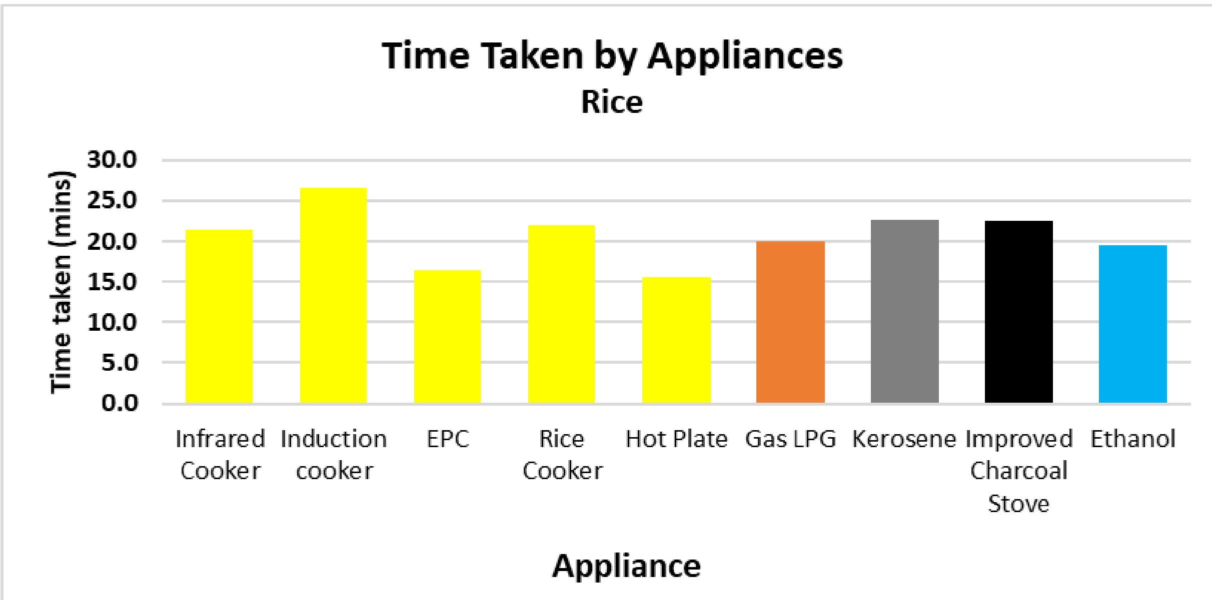

Figure 25: Average cooking time for rice (minutes).

A cost analysis shows kerosene to be the most expensive cooking fuel and can be compared with the infrared and induction stove on the band 2 tariff. The EPC was the most cost-efficient appliance due to its cooking technology. Once the heating element is heated, a high-pressure environment is created within the sealed internal pot. Cooking under the increased pressure reduces cooking times significantly, while evenly cooking the food thus reducing the energy cost. This combination of heat and pressure inside the electric pressure cooker accelerates the cooking process.

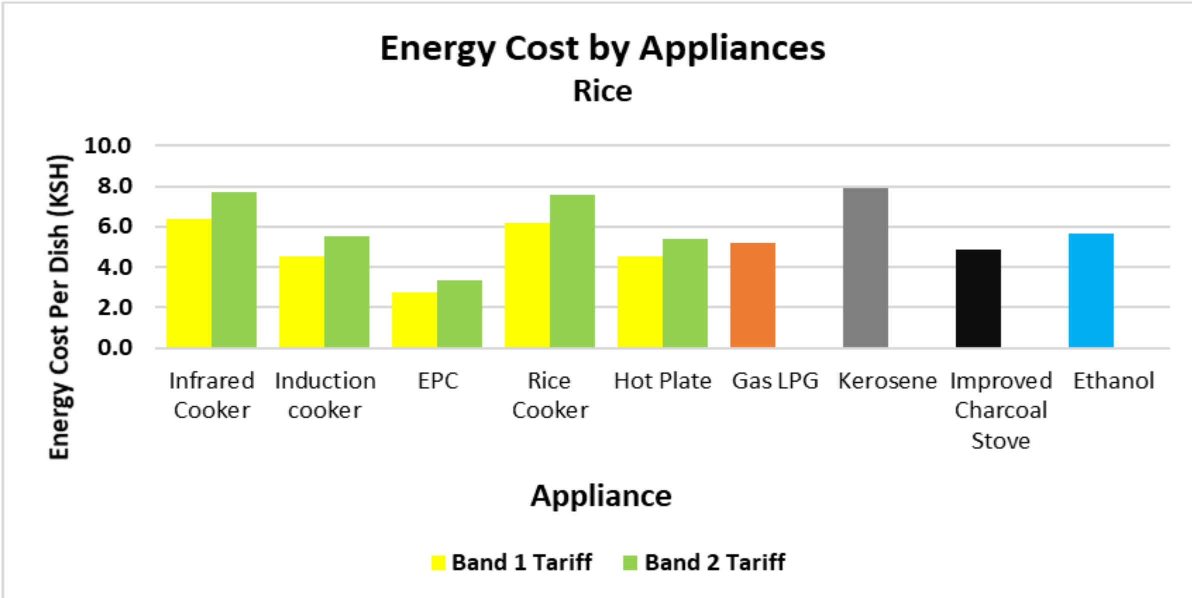

Figure 26: Average cost (KES) of cooking rice across all appliances

Spinach:

Spinach was washed and chopped into thin slices then sautéed using oil and salt for seasoning across all appliances.

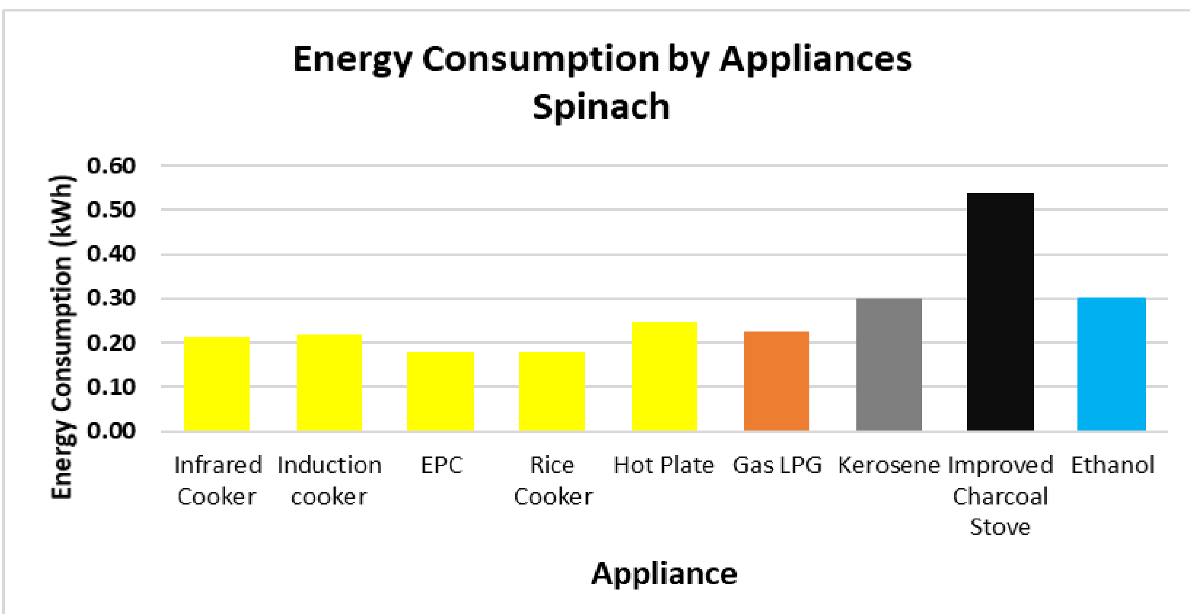

Figure 27: Average Energy Consumption for Spinach across all appliances

The rice cooker and the EPC show the lowest energy consumption rates, indicative of their higher efficiency for cooking quick-to-prepare dishes like spinach. Along with the rest of the electrical appliances, they cook spinach under 0.25kWh. The improved charcoal stove (ICS) shows the highest energy consumption among all the appliances, which is particularly significant given that spinach cooks quickly and the high energy use can be seen as an inefficiency. This could be due to the intrinsic nature of charcoal, which may not be optimal for cooking foods that require short cooking durations due to longer heat-up times and difficulty in controlling the cooking temperature. Apart from the charcoal stove, which took 18 minutes, all appliances cooked spinach between 10-14 minutes. The quick cooking times are advantageous, as spinach is a delicate vegetable that cooks rapidly and does not require prolonged heat exposure. Though the design of the ICS is typically aimed at fuel efficiency rather than speed, it indicates that it may not be the ideal choice for cooking foods like spinach that benefit from a swift cook.

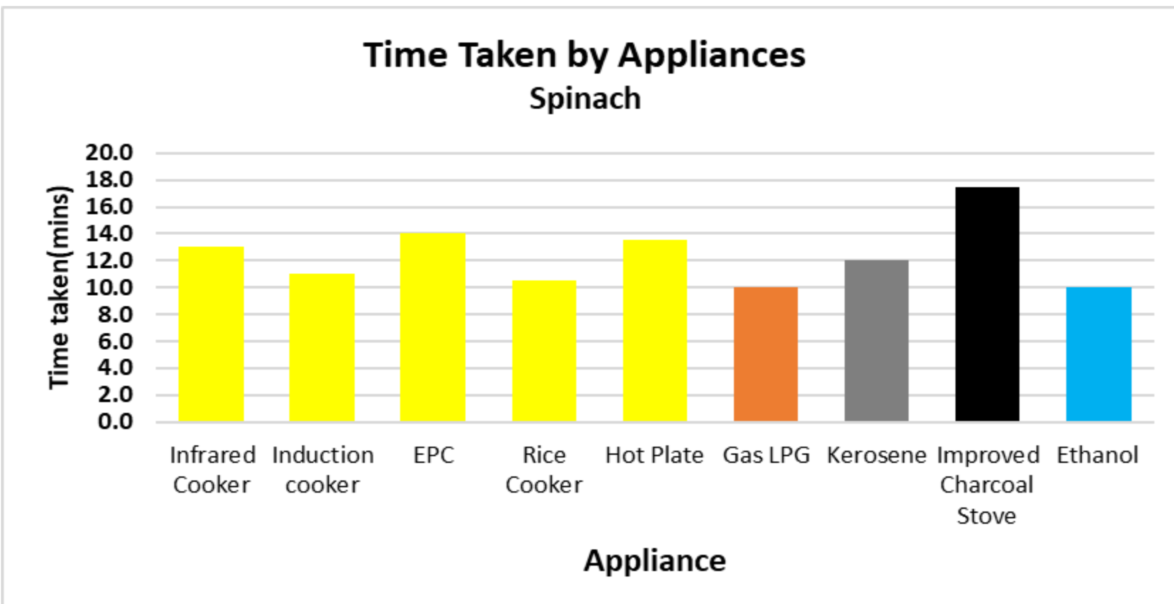

Figure 28: Average time taken for Spinach across all appliances.

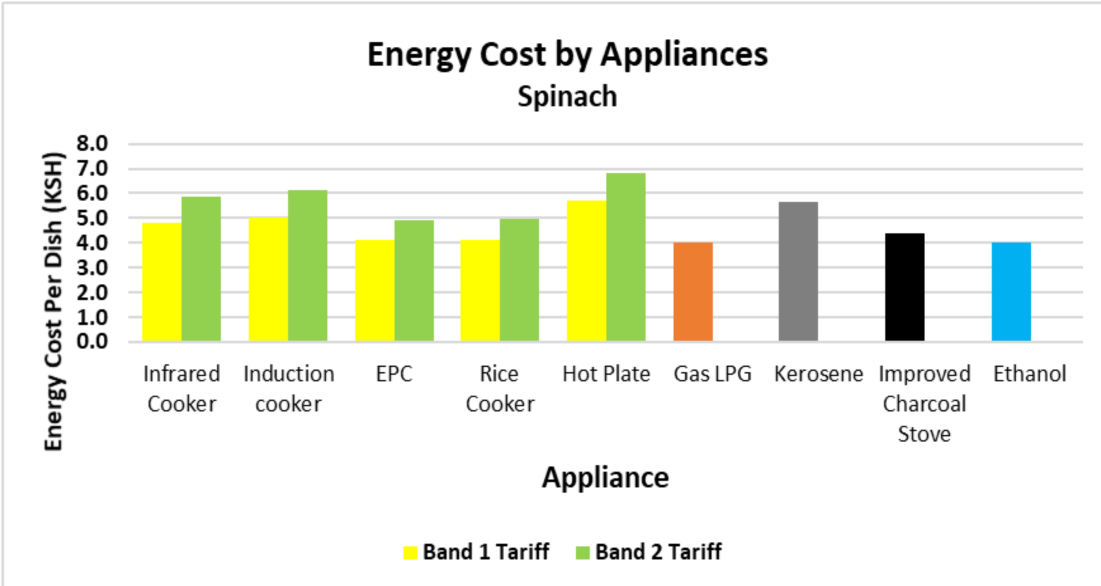

Figure 29: Average cost of cooking spinach

It costs less than 6 KES to cook spinach on the electrical appliances in the band 1 tariff. This would be beneficial for households with minimal energy usage, allowing for the cost-effective cooking of quick-cooked vegetables like spinach. Though the electrical appliances show increased cost under the band 2 tariff, they remain on the lower end, suggesting they are an economical choice for energy-conscious consumers. The LPG and ethanol cookstoves cost the least to cook spinach with and this can be attributed to their high, wide flame that is convenient for fast-cooking foods like spinach.

4.1.1. Chips:

Chips were the only meal amongst the tests that required deep frying. The chips were peeled, washed, then sliced into strips and dried before deep-fried in oil. Ideally, when it comes to deep frying, the device that can achieve the desired texture and crispness in the shortest time possible is preferred. Across all the cooking appliances, the cooks preferred the chips that were made in the LPG cooker as it was able to achieve the taste and crispness desired. This can be attributed to the high heat flame and temperature regulation of the cooker used to maintain a consistent flame for deep frying.

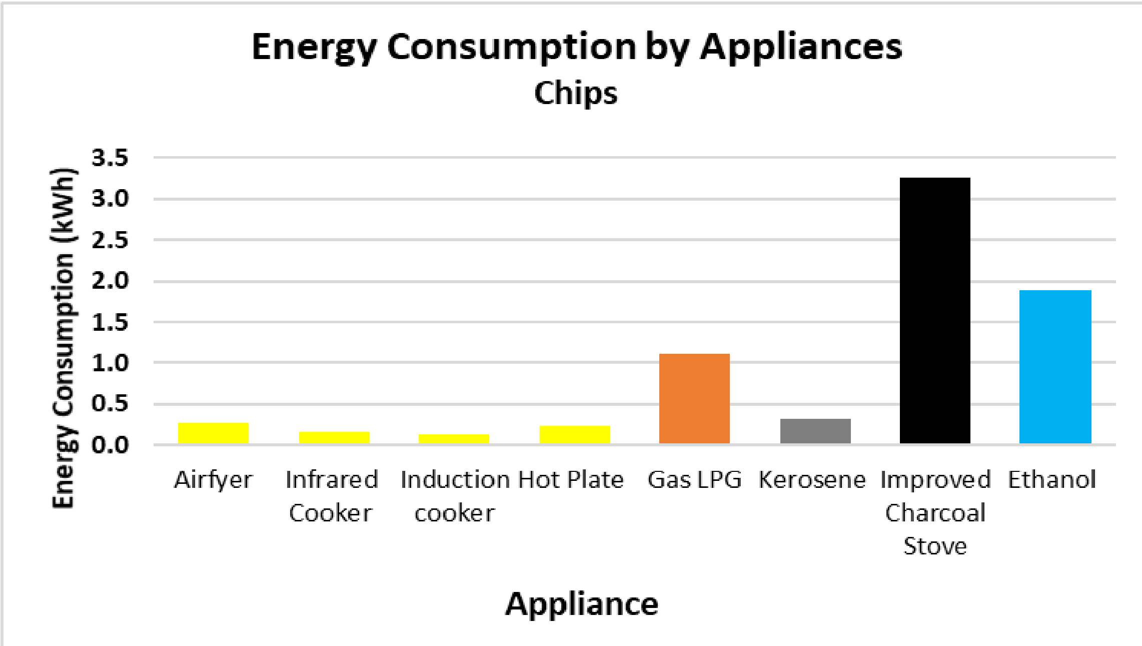

Figure 30: Average energy consumed for cooking chips.

The air fryer, known for its energy efficiency and health benefits, was amongst the lowest energy-consuming appliances as it cooks food by circulating hot air thus requiring less energy than traditional frying methods. The chips made in the air fryer were well done but their appearance wasn't as appealing as the chips made from the other cookstoves. However, it is the induction that was the most efficient in this study. This can be attributed to its use of electromagnetic fields to heat the cookware directly, reducing energy loss and thus consuming less energy. The cooks, however, noted that the chips made from the induction cooker came out soggy.

The improved charcoal stove has the highest energy consumption on the graph, which could be due to several factors including the inefficiency of heat transfer in open-fire stoves and the time it takes for charcoal to reach the necessary temperature to fry chips effectively. Surprisingly, kerosene consumed equally low energy for cooking chips though they are not known to be the most efficient of appliances.

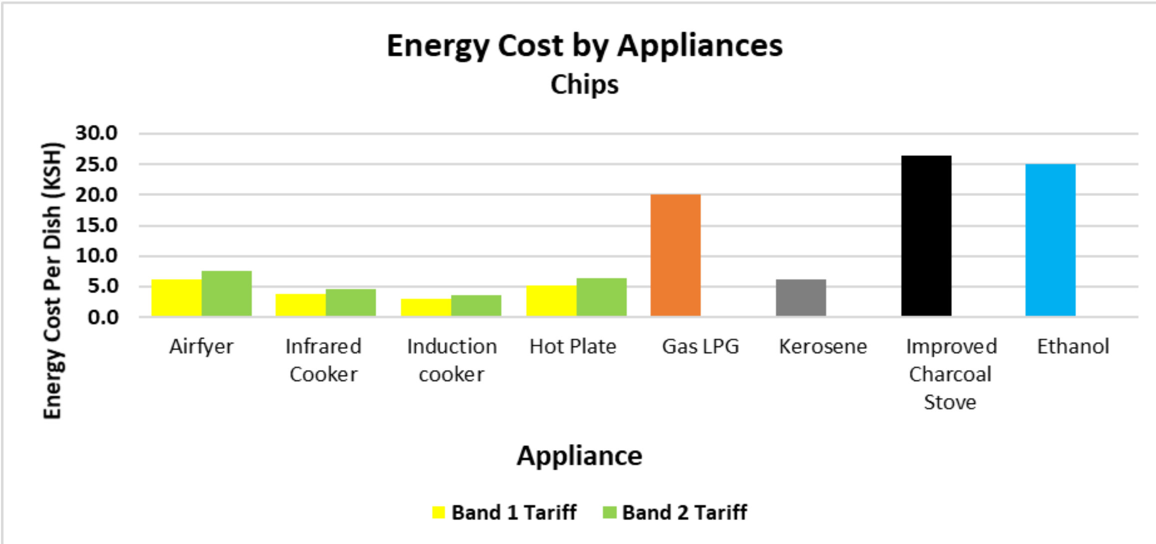

Figure 31: Average Cost of Cooking Chips

All electrical cooking appliances proved to be more cost-effective (4 times less), as compared to the LPG, despite having a low rating in taste and appearance of the chips as seen in Figure 31. Cooking chips with the ICS and ethanol stove is the most expensive compared to LPG and kerosene. Kerosene costs the same with electrical appliances and though this may be an energy cost saver for low-income households and street food vendors with thin profit margins, the low operational costs of using kerosene could be outweighed by the health and safety risks of using it over time.

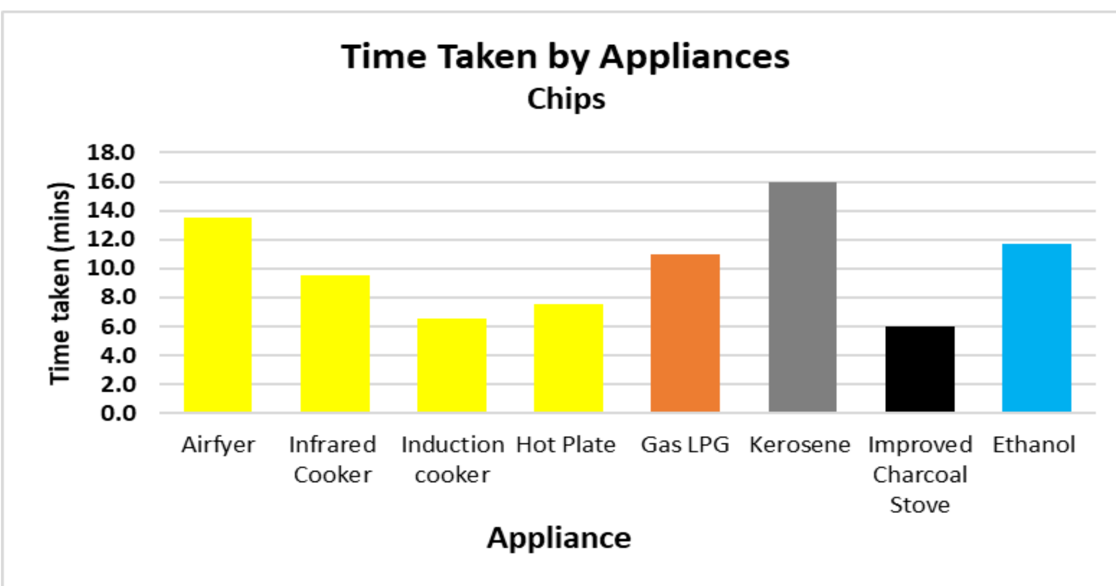

Figure 32: Average time taken to cook the chips.

The results shown in Figure 32 showed that the induction cooker took the least amount of time out of all electrical appliances. The induction cooker uses electromagnetic induction to heat the cooking pot directly. This leads to a fast, efficient heat transfer mechanism which in turn contributes to the shorter cooking time. The air fryer used rapid hot air circulation to cook food. Though they are generally efficient, the circulating hot air might not provide the same direct and intense heat as the induction, hot plate, or infrared cooker, potentially leading to a longer cooking time. Direct application of heat can result in faster cooking times, especially in foods like chips which apart from when using the air fryer, must be deep fried in oil. The ICS took the least amount of time across all appliances, slightly faster than the induction cooker. Given that the ICS is designed to optimize combustion, the cook stove can supply a steady and concentrated heat source which can lead to faster cooking times. Charcoal has a high energy density and when burned in a cooker designed to reduce fuel consumption by more than 50%, it burns efficiently.

Figure 33: Cooks display some of the air fryers used in the study.

Chapati

Flour, salt, sugar, warm water, and oil were used to prepare the dough for the chapati. The dough was covered and let to rest for 30 mins before being rolled out and cooked on the griddle frying pan on each appliance.

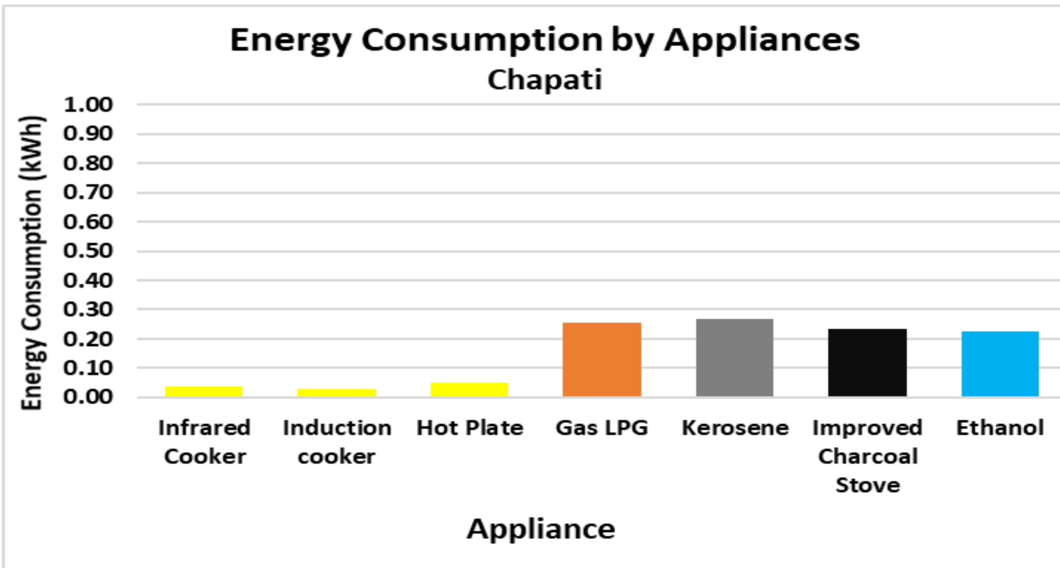

Figure 34: Average energy consumed for Chapati.

The data in Figure 34 shows that non-electrical cooking appliances are energy-intensive when cooking chapatti. That could be caused by the high yet unevenly spread-out heating of the pan during cooking. The electrical appliances consumed roughly the same amount of energy. The hot plate consumed slightly more energy amongst the three as it relies on direct heating for cooking and a significant amount of heat can be lost to the surroundings. The induction cooker proved to be most efficient due to its electromagnetic induction heating which results in rapid and efficient heat transfer.

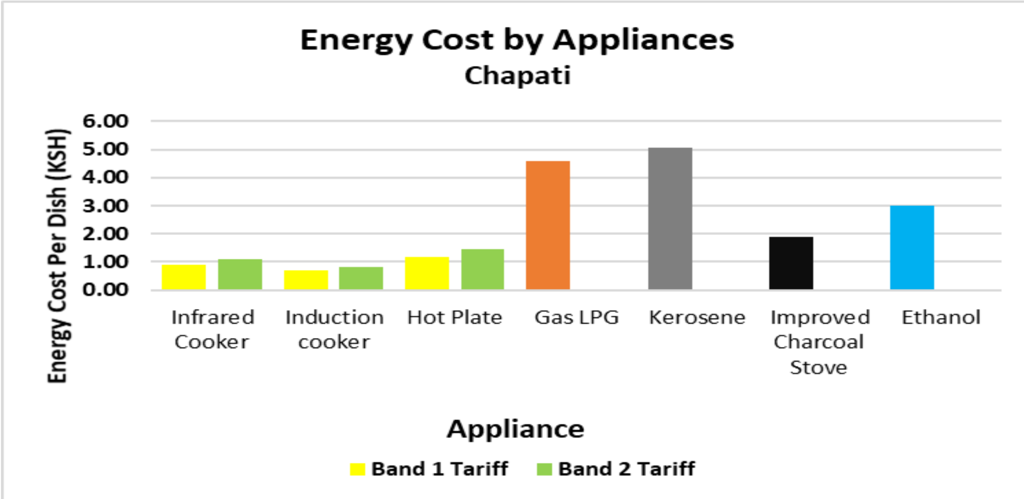

Figure 35: Average cost of cooking chapati

Although the energy cost across all appliances is low, kerosene and LPG are shown to be the most expensive in this context. This high cost is reflective of the inherent inefficiencies associated with the burning of these fuels, such as slower heat transfers and the potential for incomplete combustion, which can lead to greater fuel consumption and higher costs.

The electrical appliances show low costs under both tariff bands, less than Ksh 2. The infrared and induction cookers are particularly notable for their efficiency, exhibiting lower energy costs under both tariffs, with the induction cooker maintaining this efficiency advantage. This underscores the induction cooker's ability to directly heat the cooking vessel with minimal energy loss, making it a cost-effective option regardless of energy usage levels.

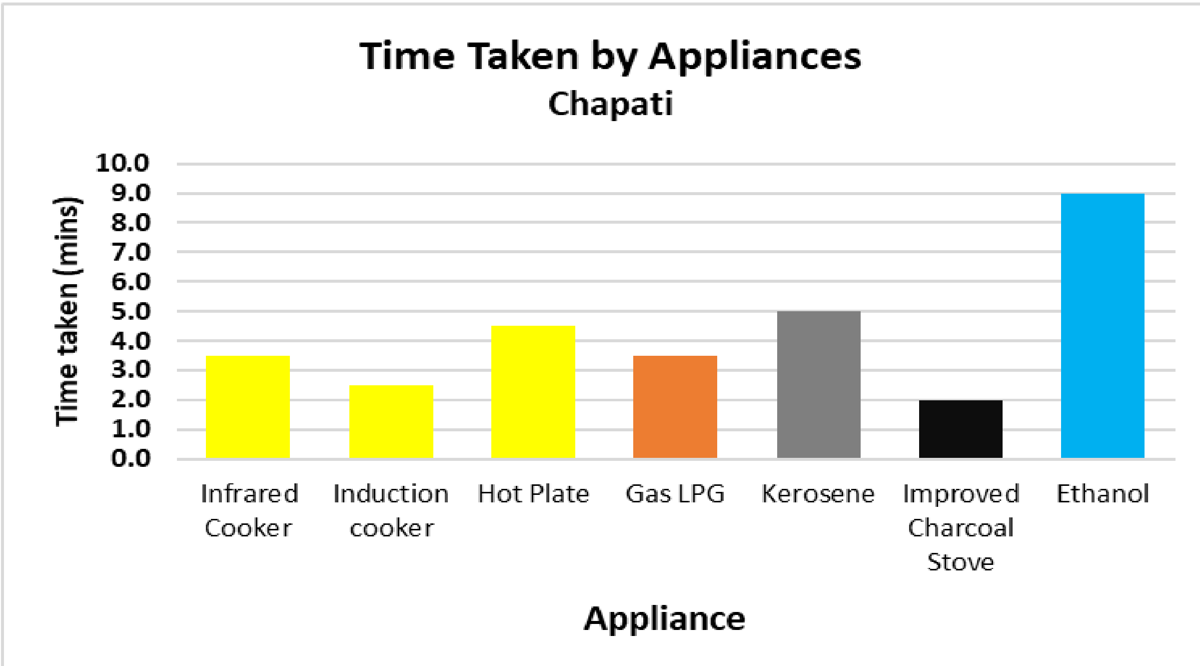

Figure 36: Average time taken to cook chapatis.

The ethanol stove ranked as the slowest performer, requiring approximately 9 minutes to complete the task, nearly twice as much time as the infrared and induction cooker. This could be attributed to the time taken to heat the pan before being able to cook. The ICS used the least amount of time among all appliances. The induction cooker took the least amount of time to cook the chapatis, proving to be the most efficient.

The reliability of the chapati tests may be subject to some limitations due to their relatively shorter duration and the methodology employed. In comparison to tests involving other dishes such as beans, where slight variations in cooking time might not significantly impact results, the chapati tests are more sensitive to relatively small errors. It's worth noting that there were only two repetitions of the chapati tests, which may not provide a comprehensive view of their performance across different fuel types. This limited sample size can contribute to variations in the results, further affecting their reliability. Hence, it is observed that the chapati tests do not consistently follow the same trend as the other dishes tested on non-electrical appliances. This discrepancy is particularly evident in the areas of cost, time, and energy consumption. While the chapati tests offer valuable insights, it is essential to consider their limitations, especially concerning their sensitivity to small cooking variations and the relatively small number of repetitions. These factors may impact the overall reliability of the chapati test results, and as such, they should be interpreted cautiously when making assessments and drawing conclusions.

4.2 Taste and Ease of Use Ratings from the Cooks

8 cooks participated throughout the cooking process, and each participating cook was assigned the responsibility of evaluating the meals prepared by each appliance. As part of the evaluation process, each cook tasted every meal and provided a numerical score on a scale of 1 to 5, with 1 representing the lowest rating and 5 representing the highest rating. These scores were based on the individual assessors' subjective perceptions of both the flavour and overall palatability of the meals. Furthermore, they also assessed the user-friendliness of the appliances, considering factors such as ease of operation, cleanliness, and the need for refueling.

Below is a heatmap displaying these ratings, along with the overall average rating for each appliance across all the meals it prepared. Subsequent visuals provide more detailed insights, contributing to a more comprehensive understanding of this evaluation.

Table 8: Heat map showing the ease of use of the appliances.

	Rating(Ease of Use)							
	Beans	Beef	Chapati	Chips	Ugali	Spinach	Rice	Total Average
EPC	5	5			3.57	4.71	5	4.66
Induction	4		4.14	3.83		4.86	3.5	4.07
Rice Cook	3.33					3.57	5	3.97
Air fryer				3				3
Infrared	3		4.14	3.33		4.71	2.67	3.57
Hot plate	2.67		3.14	3		3.29	2.33	2.89
Gas cooke	2.5	3.71	4.43	4.67		5	3.17	3.91
Charcoal	1.33	2	2.57	1.17		2.86	2.17	2.02
Ethanol	1.83		4.43	3		3.14	1.5	2.78
Kerosene	1.33		3.14	2.33		1.57	1	1.88

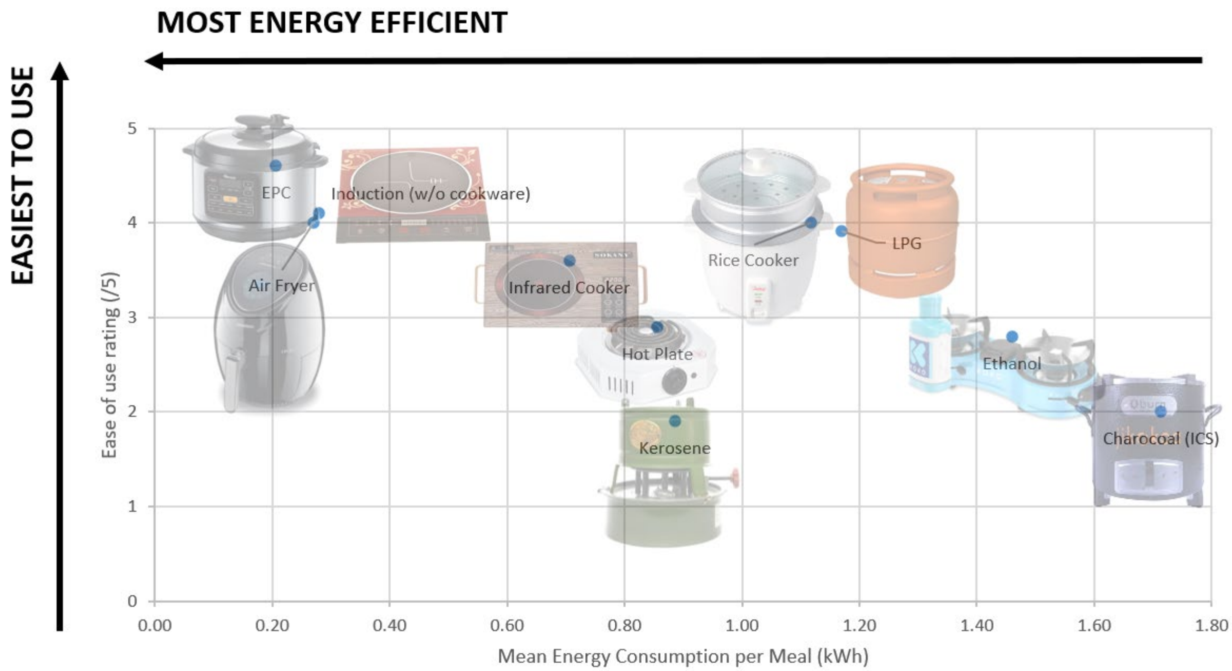

Figure 37: evaluates the energy-efficiency against the ease of use and versatility.

Table 9: Heat map showing the taste of the meals prepared.

	Rating Taste of Meals							
	Beans	Beef	Chapati	Chips	Ugali	Spinach	Rice	Average
EPC	5.00	5.00			4.43	4.43	5.00	4.77
Induction (	4.33		4.83	2.57		4.57	4.00	4.06
Rice Cook	4.17					4.43	5.00	4.53
Air frier				3.00				3.00
Infrared	3.83		4.29	2.86		4.00	4.00	3.80
Hot plate	4.17		3.71	3.57		3.43	4.00	3.78
Gas cooke	4.50	4.86	4.71	5.00		4.57	4.00	4.61
Charcoal	4.33	4.29	3.00	2.71		4.00	4.00	3.72
Ethanol	4.67		5.00	3.29		4.00	4.00	4.19
Kerosene	3.83		3.14	3.29		4.00	4.00	3.65

The kerosene cook stove ranked the lowest in terms of ease of use of the appliance. The stove cooked slowly and produced soot which resulted in the cook experiencing headaches. The soot not only affected the appearance but also introduced an unpleasant, smoky taste and gritty texture to the dishes. Handling was also problematic for the stove during weighing and moving around as it would get very hot on the sides. The odour of kerosene during cooking affected the degraded flavour of the food.

For the charcoal stove, the taste of the meals ranked above average apart. The chips when cooked with the ICS came out crunchy.

The electric pressure cooker (EPC) stands out as the top-rated appliance by the cooks. For hard foods that require boiling like beef and beans, the EPC was rated to be the appliance with the most ease of use and gave the tastiest of meals. This is seen with rice as well. Through automatic pressure and temperature regulation, EPCs (Electric Pressure cookers) provide an efficient and time-saving method of cooking for a wide range of foods. The sealed cooking environment in the EPC effectively preserves the natural taste of ingredients, allowing them to maintain their original flavors.

The LPG cooker ranked highly when it came to the taste of the food, close to the EPC and induction cooker. It ranked the best when it came to cooking chips as it cooked them to the desired texture and crunchiness in comparison to the other cookers, according to one of the cooks. With its ability to regulate heat, the cooker ensures even and consistent cooking, enhancing the taste and texture of the dishes. Its rapid and efficient heat source reduces cooking times making it an easy appliance to use as seen with the ranking given for spinach.

The Induction Cooker ranked as the 4th out of the 10 cooking appliances in terms of ease of use and taste. Induction cookers use heat to cook produced by strong electric fields. They are safe and efficient appliances since they don’t use direct heat or flames. In the test, it ranked low in taste when making chips and was a moderately hard appliance to use when preparing rice.

Table 10 gives some of the issues that were identified by the cooks while using the appliances.

This table is meant to be a guide to the user and doesn't influence the analysis made in this study.

Table 10: Issues raised by the cooks while using the appliances.

Appliances/ Stoves	**Rate of ease of use**	**Taste of meals**
EPC 	The inner spot spins when cooking	
Induction Cooker 	Chips **3.83** -getting the right settings for deep frying was a challenge. Rice **3.5**- changing power and temperature settings	Chips 2.57- The chips weren't as crispy and dry as the rest
Rice cooker	Beans and spinach- controlling the food water content is the reason for the rating	

		
Air fryer 		The chips were well cooked on the air fryer though they looked unappealing compared to the chips cooked by the rest of the appliances
Infrared 	Rice- controlling cooking settings both temperature and power was a challenge.	The chips weren’t as dry and crispy as the rest. The beans were semi-heard and not as well cooked compared to the rest of the appliances.
Hot plate 	Beans and rice- longer cooking time due to the hot plate heat distribution	Spinach was overcooked. The chips were not as crispy
Gas cooker (LPG) 	Beans 2.5 – boiling, watching over the pot took so much effort to prevent the food from burning and under cooking	Beans are not as tasty as the EPC ones
Improved charcoal stove	Adding charcoal all the time, lighting the charcoal which had to be done using the hot plate which smoked and created soot. Allergic reactions are caused by using the charcoal from some of the cooks.	Chapati was very dry and the chips were soggy

		
Ethanol 	Addition of ethanol throughout the cooking time and monitoring of heat levels	Chips are not as tasty as the gas cooker ones
Kerosene 	The whole process of lighting a kerosene stove created so much soot, allergic reactions, and having to switch off the stove away from people to prevent further soot, cross contamination of the kerosene oil, and post cooking kerosene smell	Chips were not as tasty as the ones made on the LPG stove.

From the CCTs, the Electric Pressure Cooker (EPC) had a notable rating of 3.57 for its ease of use when cooking ugali. However, the spinning pot inside that moved while making Ugali made the cooking experience a bit difficult. It would need the cook to constantly hold down the pot at the sides just as when cooking ugali with an ordinary sufuria on other cooking appliances. The Induction Cooker, on the other hand, had a moderate ease-of-use rating of 3.83. Despite its ease of use, achieving the right settings for deep frying, as evidenced by a rating of 2.57 for Chips, proved challenging. Additionally, the Chips prepared with the Induction Cooker did not turn out as crispy and dry as those from other devices.

The Rice Cooker presented mixed results in the study. While it performed well with Beans and Spinach, the control over food and water content played a significant role in the rating. The chips made from the air fryer were well done though they were not as appealing in appearance compared to the chips made from the other cookstoves. The Infrared cooker also faced difficulties, especially with Rice, where controlling cooking settings for both temperature and power proved challenging. Similarly, the Chips cooked with the Infrared cooker weren't as dry and crispy as desired.

The Hot Plate exhibited varying cooking outcomes. It required longer cooking times due to uneven heat distribution, particularly when preparing Beans and Rice. However, it had the advantage of shorter cooking times for dishes like Spinach and Chapati. Unfortunately, Spinach was often overcooked on the Hot Plate, and the Chips did not turn out as crispy as desired. When using a Gas Cooker, there was a substantial effort involved in watching over the pot to prevent the food from burning or undercooking leading to a rating of 2.5 for Beans. Additionally, Beans prepared in the Gas Cooker were not as tasty as those cooked in the Electric Pressure Cooker (EPC). The use of Charcoal and Kerosene stoves presented various challenges, including the constant need to add fuel and issues with soot, smoke, and allergic reactions. The resulting dishes, such as Chapati and Chips, also fell short of expectations in terms of taste and texture compared to their gas-cooked counterparts.

Conclusion.

In this comprehensive study comparing a diverse array of cooking appliances across various meals, several crucial factors come to light, influencing the overall performance and user experience. The Electric Pressure Cooker (EPC) emerges as a standout performer, excelling in energy efficiency, versatility, and cost-effectiveness. Its ability to cook a range of foods, including beans, beef, rice, and spinach, in a relatively short time (e.g., one hour for beans) while consuming minimal energy positions it as a top choice for those seeking an all-encompassing solution. The EPC's sealed cooking environment preserves the natural taste of ingredients, and its integration of pressure and heat ensures faster cooking times, making it an invaluable addition to the modern kitchen.

On the other end of the spectrum, traditional cooking methods involving kerosene and charcoal stoves exhibit drawbacks that extend beyond mere energy consumption. These methods not only prove to be less cost-effective but also introduce challenges related to soot production, allergic reactions, and post-cooking odors. The overall cooking experience with these stoves, as reported by users, is marred by constant fuel replenishment and comprises taste and texture. The compromise in the taste and texture of dishes cooked on these stoves highlights a significant tradeoff between convenience and cooking outcomes. These findings underscore the importance of moving towards more efficient and cleaner energy sources for cooking.

To enhance objectivity in future appliance comparison tests, blind taste tests are recommended for the evaluation of the meals. This approach aims to eliminate any potential biases that may arise from participants' preconceived notions or preferences for a particular brand or cooking method.

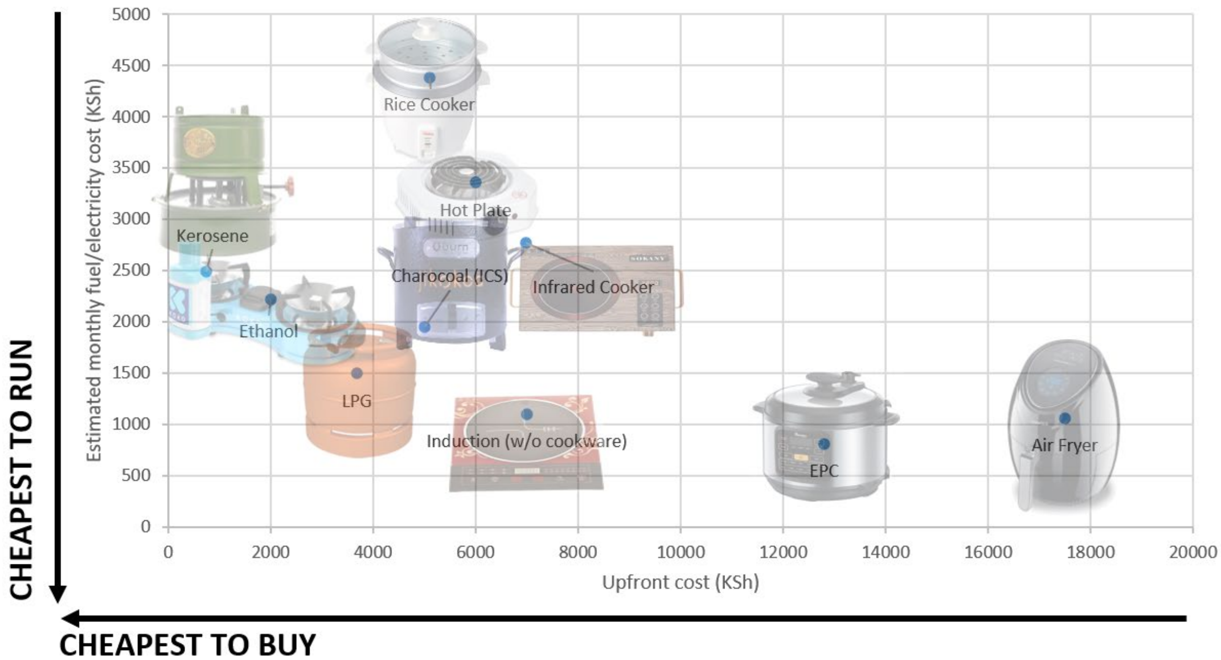

Figure 38: Figure 10: Comparison of upfront and estimated ongoing costs for each cooking device. Ongoing cost estimated by modeling a typical weekly menu consisting of 5 of each dish type. For appliances unable to cook all dish types (rice cooker, EPC, air fryer),

For the above cost-analysis, it is assumed that beans, rice, and spinach are cooked twice a week while chips and chapati are cooked once a week. The air fryer has been included in the analysis based on the cost-effectiveness of the appliances. However, in terms of versatility, it is very limited as only one meal was tested here i.e. chips.

The EPC has a high upfront cost but low running costs suggesting that while the initial investment is high, it could prove to be more economical over its lifespan due to savings in operational expenses. It combines the benefits of pressure cooking with electricity's efficiency, resulting in lower energy usage over time, as was indicated by its low energy consumption and quick cooking times. The induction and infrared cooker are less expensive to purchase than the EPC, but the induction cooker has a higher energy saving potential and lower operating costs than the infrared cooker reflecting the energy efficiency of induction cooking technology. Induction cookers are known for their rapid heating and precise temperature control, which contributes to their moderate running costs. The LPG, rice cooker, induction cooker, and EPC have considerably low operating costs in comparison to their upfront costs. The kerosene stove has the lowest upfront costs of all appliances but denotes higher running costs hence while it may be a cheap household cooking appliance to acquire, its low efficiency and high energy costs could make it expensive over its lifetime. While also taking into consideration the health and safety risks associated with the stove. For the ICS, its upfront cost could be considered affordable, but the data shows the appliance to be the least efficient apart from when making chapati. This could be favorable for street vendors who sell chapati as they are not worried about the time taken to heat the appliance as compared to households.

References

Berkouwer, S. B., & Dean, J. T. (2022). Credit, Attention, and Externalities in the Adoption of Energy Efficient Technologies by Low-Income Households. *American Economic Review*, *112*(10), 3291–3330. https://doi.org/10.1257/aer.20210766

Chepkemoi, M., Leary, J., Adhiambo, S., & Atela, J. (n.d.). *COOKING DIARIES KENYA POLICY DIALOGUE REPORT*.

Customs and Cuisine of Kenya—Together Women Rise. (n.d.). Retrieved November 19, 2023, from https://togetherwomenrise.org/customsandcuisine/customs-and-cuisine-of-kenya/

Energy-and-Petroleum-Statistics-Report-2019.pdf. (n.d.). Retrieved November 20, 2023, from https://www.epra.go.ke/wp-content/uploads/2020/09/Energy-and-Petroleum-Statistics-Report-2019.pdf

EPRA. (2023, March 24). RETAIL ELECTRICITY TARIFF REVIEW FOR THE 2022/23-2025/26 4TH TARIFF CONTROL PERIOD (TCP) EFFECTIVE 1ST APRIL 2023. *Energy and Petroleum Regulatory Authority*. https://www.epra.go.ke/retail-electricity-tariff-review-for-the-2022-23-2025-26-4th-tariff-control-period-tcp-effective-1st-april-2023/

Batchelor, S. (2023). Energy Transfer in Kitchen Appliances. *Modern Energy Cooking Services*. https://mecs.org.uk/blog/energy-transfer-in-kitchen-appliances/

Gonzalez, A. (2020, October 30). *Beyond bans: Toward sustainable charcoal production in Kenya*. CIFOR Forests News. https://forestsnews.cifor.org/68884/beyond-bans-toward-sustainable-charcoal-production-in-kenya?fnl=

Kenya_clean_cooking_energy_compact_08_november_2021.pdf. (n.d.). Retrieved November 19, 2023, from https://www.un.org/sites/un2.un.org/files/2021/11/kenya_clean_cooking_energy_compact_08_november_2021.pdf

kenya-cooking-sector-study—Abridged-_eed-2019.pdf. (n.d.). Retrieved November 20, 2023, from https://cenareadvisory.com/media/attachments/2019/11/10/kenya-cooking-sector-study---abridged-_eed-2019.pdf

Kenya_MoE-Kenya Cooking Sector Study_2019.pdf. (n.d.). Retrieved November 19, 2023, from https://rise.esmap.org/data/files/library/kenya/Electricity%20Access/Kenya_MoE-Kenya%20Cooking%20Sector%20Study_2019.pdf

KPLC Annual Report 17_12_2018_Wed.pdf. (n.d.). Retrieved November 19, 2023, from https://www.kplc.co.ke/AR2018/KPLC%20Annual%20Report%2017_12_2018_Wed.pdf

Leary, D. J. (n.d.). *MECS Controlled Cooking Test (CCT) Protocol*.

Nation. (2022, November 24). *Kemri: 23,000 Kenyans die yearly from cooking with kerosene, firewood, and animal dung*. Nation. https://nation.africa/kenya/news/kemri-23-000-kenyans-die-yearly-from-cooking-with-kerosene-firewood-and-animal-dung-4031260

Osiolo, H. H., Marwah, H., & Leach, M. (2023). The Emergence of Large-Scale Bioethanol Utilities: Accelerating Energy Transitions for Cooking. *Energies*, *16*(17), Article 17. https://doi.org/10.3390/en16176242

Perros, T., O'Keefe, M., Mwitari, J., Gichane, L., Puzzolo, E., & Pope, D. (2023). Controlled cooking tests comparing the financial, energy, and time costs of different food and stove combinations in Nairobi, Kenya. UCL Open: Environment Preprint. https://doi.org/10.14324/111.444/000214.v1

Scaling-up-clean-cooking-in-urban-Kenya-with-LPG-and-Bio-ethanol.pdf. (n.d.). Retrieved November 20, 2023, from https://southsouthnorth.org/wp-content/uploads/2018/11/Scaling-up-clean-cooking-in-urban-Kenya-with-LPG-and-Bio-ethanol.pdf

The-Kenya-eCookbook-Beans-Cereals-edition-3-July-FULL-RECREATED-WEB-1-4mb.pdf. (n.d.). Retrieved November 20, 2023, from https://mecs.org.uk/wp-content/uploads/2021/01/The-Kenya-eCookbook-Beans-Cereals-edition-3-July-FULL-RECREATED-WEB-1-4mb.pdf

Appendix

2. Recipes

Chapati

Ingredients

- 10 cups all-purpose flour
- 4 tsp salt
- 4 tbsp. sugar
- 12 - 20 tbsp. oil
- 5 cup warm water
- 24-32 tsp ghee, butter or oil
- Extra flour for dusting
- 25 tsp oil for roasting

Preparation

1. Add flour, salt, and sugar to a mixing bowl. Mix well.
2. Add 12-16 tbsp. oil and rub into the flour.
3. Add the measured warm water and form a soft dough. Add any extra water required, tablespoon at a time as you don't want the dough too soft.
4. The dough should not be sticky.
5. Take a tbsp. of oil and knead it into the dough.
6. Cover the dough with a damp cloth, lid, or cling film. Allow the dough to rest for 30 minutes.

Method

1. Heat a griddle frying pan over medium heat.
2. Place the rolled-out chapati over the griddle. Allow it to roast for 1-2 minutes.
3. Flip it over and allow the other side to roast for 1-2 minutes.
4. Smear about 1 tsp oil, ghee, or butter all over the top side. Flip it over.
5. Roast or cook till brown specks appear.
6. Smear oil, ghee, or butter on the top dry side.
7. Flip and roast. Roast till the chapati is done. You should see brown specks all over the chapati and some of the layers should come apart.
8. Repeat the same with the remaining dough.
9. Serve hot Kenyan Chapati with your favorite curry or stew. Or serve it hot with some tea

Vegetables (Spinach)

Ingredients

1. 290g of spinach
2. 93g red onion
3. 114g tomatoes
4. Salt to taste
5. 35 g Vegetable oil

Preparation

1. Wash and roughly chop your spinach leaves.
2. Wash and chop the onions and tomatoes.

Method

0. Saute the onions in oil for six minutes until they turn translucent.

1. Add the tomatoes and let them cook slightly before adding the spinach on top.

0. Keep stirring and saute for 10 minutes while uncovered.

1. Add salt to taste and serve.

Beef stew

Ingredients

500 g of beef
2 tablespoons of cooking oil
150g onions
115 g tomatoes
1 green capsicum
1 teaspoon of salt.
2 cups of hot water
1 beef cube as stock

Method: Boiling and Frying

1. Cut the beef in dices.
2. Boil the diced beef in garlic and salt in the EPC/pot until tender. Set
3. aside once ready.
4. Add the diced onions into the EPC/pot cooking pot and fry in oil until
5. light brown.
6. Add the tomatoes and let them cook to give a
7. thick paste.
8. Add the boiled beef.
9. Add water and soy sauce.
10. Cover EPC/pot and boil for 10 mins
11. Once the timer goes off for the EPC, do a quick manual pressure release and serve to taste.

Chip

Ingredients

½ Kg Potatoes
3 Cups Vegetable Oil
Pinch Salt

Preparation

Peel, wash your Potatoes, and cut them into long thin, or thick strips.

Method

1. Drain the water and then place on a kitchen towel to absorb the moisture.
2. Heat your deep-frying pan till the oil is hot enough.
3. Carefully drop the sliced Potatoes in batches into the hot oil and let them cook.
4. Once they start to float since they are no longer heavy. Use a ladle to check if they have started turning golden yellow.
5. Let the Potatoes cook some more as you check for their doneness.
6. Remove the French Fries from the oil and let the excess oil drip off.
7. Set the French Fries in a large bowl with a paper towel to keep warm as you finish the remaining batches.

Ugali

Ingredients
Maize flour
6 cups of water

Method

1. Heat 3 cups of fresh water in an EPC which is cooked till the water is brought to boiling point. Pour half a cup of flour into the pressure cooker.
2. Allow water to keep boiling for a few minutes, and then begin to turn the mixture with a long wooden spoon.
3. The rest of the flour is added in portions and stirred well until it becomes firm.
4. Continue to mix and press it against the walls of the cooking pot until all flour is mixed in.
5. The cooking pot is then covered with its lid and let to cook for 15 minutes

Beans

Ingredients
250 g of beans
35 g of cooking oil
150 g of onions
115 g tomatoes
14g garlic paste.
12 g ginger paste
Salt to taste

Method: Boiling and Frying

1. Soak the beans overnight.
2. Boil the beans in a pot or under the beans setting in the EPC. Set aside once ready.
3. Add the diced onions into the EPC /cooking pot and fry in oil until light brown.
4. Add the ginger and garlic paste.
5. Add the tomatoes and let them cook to give a thick paste.
6. Add the boiled beans.
7. Add water.
8. Cover EPC /cooking pot and boil for 10 mins.