



## Comparison of energy use and GHG emissions when cooking roast chicken: Electric pressure cooker/air fryer vs conventional oven

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### Abstract

This study compares the energy use for cooking chicken using three different electrical appliances. The aim was to use two chicken-based recipes to compare the energy consumption of an electric pressure cooker and an air fryer with that of an electric oven. One recipe was used for comparing the energy consumption of an electric pressure cooker and an electric oven, while another was followed to compare the energy required to cook the chicken using an air fryer and electric oven. To determine the energy demand for cooking, electricity meters were connected to the pressure cooker and air fryer, while for the oven, preheating and cooking steps were timed and manufacturer information on energy consumption considered. The temperature of the chicken before and after cooking were measured, to ensure the chicken was cooked and shown similar conditions. In the case of the first chicken recipe, the pressure cooker uses on average 0.57 kWh per kg of raw chicken, which is equivalent to 81% less energy required to roast the chicken in the oven. For the second recipe, the air fryer consumed on average 0.44 kWh per kg of raw chicken; this represents on average 84% less energy than energy is consumed when cooking in the oven for the same recipe. The results were normalised by the amount of raw chicken used to make fair comparisons. These results suggest that cooking with these alternative appliances is far more energy efficient, making them cheaper to run in the household.

### Background

Households around the world are increasingly concerned about their energy consumption given the increasing contribution to living costs and to climate change.

Instant Brands commissioned an independent cooking comparison to test their belief that cooking with their devices would result in significant energy savings and reduced GHG emissions compared with cooking in the conventional ovens, as commonly used in Europe.

The work was informed by the evidence collected by the Modern Energy Cooking Services Programme<sup>1</sup> that established the high energy efficiency of electric pressure cookers along with being economical for cooking a range of East African dishes (Batchelor et al 2019).

In addition, a recent study estimated that the impact to climate change of cooking practices in the UK could account for up to 61% of the impacts of foods (Frankowska et al 2020), while in other countries this understanding is still under development (Reynolds et al 2020a,b).

## Study Methodology and Design

We carried out the study using the principles and good practice of the Controlled Cooking Test<sup>2</sup> (CCT) method developed in 2004 for the Household Energy and Healthy Programme of the Shell Foundation.

The approach and key principles are:

- Cooking comparison should be of genuine recipes that could be cooked in the target context and carried out by household cooks using normal equipment
- As far as possible conditions and approach should be standardised across multiple cooking episodes – minimum of three – keeping sources of variation, such as the cook, as minimal as possible.
- Energy use of the Instant Brands products will be measured directly using energy meters (Nevsetpo monitor plug power, electricity usage meter,)<sup>3</sup>
- Energy use of the conventional oven will be either determined by directly recording energy consumption or by timing oven usage and using manufacturers information about power and energy consumption calculations following methodology of studies in the field
- Objectively defined end-points of the cooking will be used to ensure they are equivalent.

Recipes/dishes to compare. We carried out the comparison using two different roast chicken recipes, repeating each three times in both the Instant Brands devices and in a conventional oven.

The cooking using the Instant Brands products all took place in the same domestic kitchen. The only equipment supplied by Instant Brands were the two cooking devices:

- Vortex Plus 6-in-1 Air Fryer with ClearCook & OdourErase<sup>4</sup> (used for Cajun Chicken)
- Pro Crisp 8L Multi Pressure Cooker and Air Fryer<sup>5</sup> (used for Rosemary and parmesan chicken)

See Appendix for the recipes and instructions followed.

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<sup>1</sup> <https://mecs.org.uk>

<sup>2</sup> <https://cleancooking.org/binary-data/DOCUMENT/file/000/000/80-1.pdf>

<sup>3</sup> Brand new meter from

[https://www.amazon.co.uk/gp/product/B07H1ZFVFM/ref=ppx\\_yo\\_dt\\_b\\_asin\\_title\\_o04\\_s00?ie=UTF8&th=1](https://www.amazon.co.uk/gp/product/B07H1ZFVFM/ref=ppx_yo_dt_b_asin_title_o04_s00?ie=UTF8&th=1)

<sup>4</sup> <https://instantbrands.co.uk/shop-all-products/vortex-plus-6in1-airfryer-clearcook-odouerase/>

<sup>5</sup> <https://instantbrands.co.uk/shop-all-products/pro-crisp-8l-multi-pressure-cooker-air-fryer/>

The cooking of the chicken using the comparison equipment by Instant Brands took place in a different, but similar, domestic kitchen. In all cases, the chickens were purchased from supermarkets and consumed and enjoyed by families. The domestic oven used for cooking the two chicken recipes was an electric oven of 2400W - Manual Lamona LAM3210<sup>6</sup>.

We sought to measure and control:

- Weight of chicken (from sales packaging)
- Welfare of chicken (selected free-range)
- Feeding of chicken (selected corn-fed)
- Pots used to cook chicken in (keeping the same ones for each repetition of each recipe)
- Temperature of the chicken before and after cooking were measured, to ensure equivalence and that the chicken was cooked through before ending the monitoring (domestic cooking thermometer)
- Starting temperature of the Instant Brand cooking devices – in all cases the cooking started with the devices at room temperature (i.e., not having recently been heated for previous dish)
- Oven temperature at start and at each stage (domestic oven thermometer)
- Cooking time - for the oven, preheating and cooking steps were timed (timer)
- Energy consumption of the Instant Brand devices (Nevsetpo monitor energy usage meter)

We also made informal, subjective notes and observations about the cooking experience and the final products and took photos at various points during the process.

Energy consumption was normalised with the weight of each raw chicken to account for weight difference due to difficulties finding 12 chickens with exactly the same weight.

Manufacturer information on energy consumption considered. Energy consumption of the oven was calculated following Frankowska et al (2020) using the reported rated power and measured cooking times.

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<sup>6</sup> <https://manuall.co.uk/lamona-lam3210-oven/>

## Results

The data collected and the calculations on which the comparisons were made are given in Table 1. We present the energy comparison graphically in

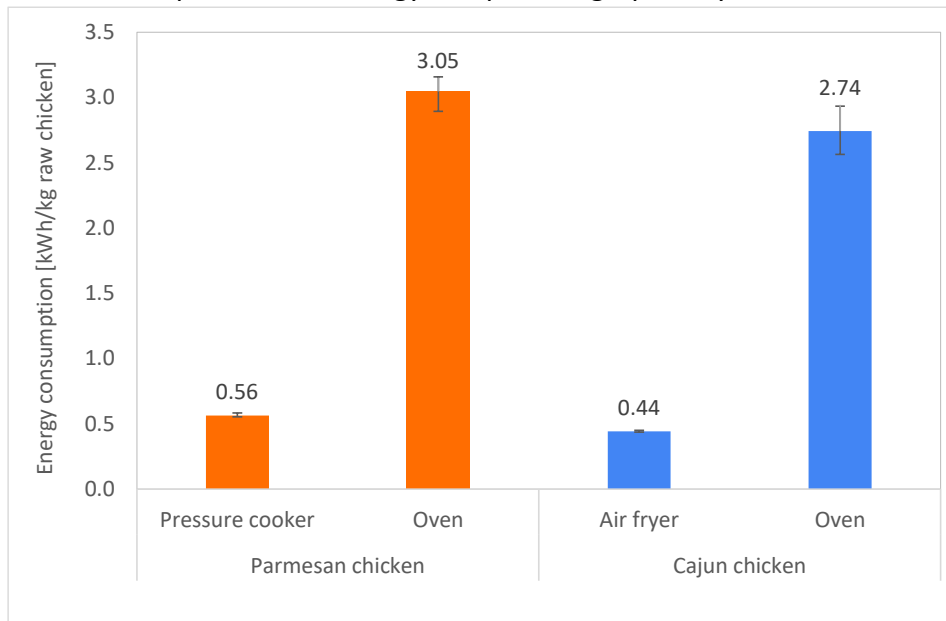


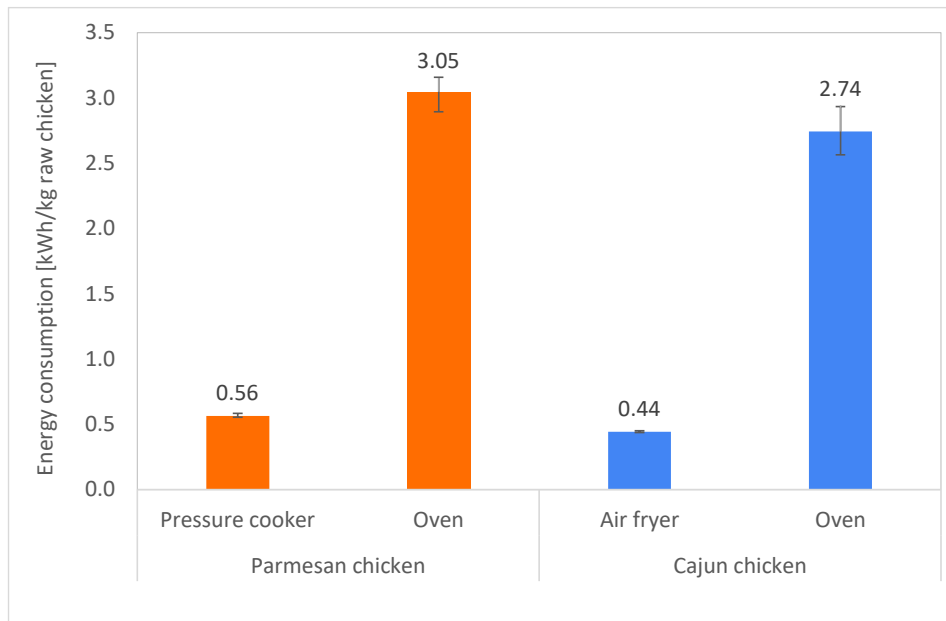
Figure 1, showing very clearly the substantial difference between the two cooking modes, found across both recipes.

The results were normalised by the amount of raw chicken used to make fair comparisons. Results are also shown per kg of raw chicken only instead of per cooked chicken as conversion factors are not known for the new appliances and the weight of the chicken could not be measured after cooking due to the additional ingredients.

In the case of the Parmesan chicken recipe, the electric pressure cooker uses on average 0.56 kWh per kg of raw chicken, which represents 19% of the energy required by the oven; this would mean a household would use 81% less energy compared with roasting the chicken in the oven. Considering minimum and maximum values, the net energy saving ranges from 4 to 4.7 times when compared with the electric oven.

Similarly, in the case of the Cajun chicken, the air fryer consumed on average 0.44 kWh per kg of raw chicken; this is equivalent to 16% the energy used by the oven; hence it represents on average 84% less energy than the consumed when cooking in the oven for the same recipe. The net energy saving of the air fryer ranges from 4.7 to 5.7 times when compared to an electric oven for the same recipe.

Subjectively, we felt both modes of cooking delivered an equivalent and very acceptable result in appearance, aroma and flavour. The rosemary and parmesan recipe involved more stages, for both forms of cooking and switching the chicken between the EPC and the air fryer arrangement resulted in some damage to the chicken which affected its appearance, on completion.



*Figure 1 Comparison of average energy consumption between pressure cooker and air fryer against oven using two chicken-based recipes per kg of raw chicken.*

## Discussion

These findings show conclusively that the two Instant Brands devices consume much less energy than an electric oven when cooking roast chicken. The findings provide a good representation of the different energy usage of the appliances studied, and their potential savings. Future extrapolations of these results need to consider differences in rated power of the appliances, the energy source (e.g., electric vs gas oven) and the user cooking practices.

We have not replicated the comparison with a selection of domestic ovens, so there remains the possibility that the comparison would vary depending on the variation of energy demand for different oven manufacturers and models. Further work would enable us to compare these findings with what is known about the different ovens used in most European households and to extend our conclusions with confidence.

Additionally, in terms of calculations, for the Instant Brand appliances, direct meter readers were used, however for the oven, installing meters were not possible due to the testing set up (e.g., existing domestic kitchen). Hence, cooking steps were timed, and temperatures recorded, and the oven reported rated power was used for calculating the energy use. The accuracy of both methods for estimating energy used need to be further explored in future studies.

Next steps include the estimation of the greenhouse gas (GHG) emissions of these cooking appliances to conclude the potential reduction of the climate change impact. However, we are confident that the findings in this study indicate significant reductions in GHG emissions.

Table 1 Raw data recorded and calculations.

Recipe	Appliance	Weight of chicken [kg]	Total Energy [kWh] <sup>7</sup>	Total Energy [kWh/kg raw chicken]	Mean [kWh/kg]	Max [kWh/kg]	Min [kWh/kg]	Comparison against oven [%]			Saving [times]			Net Saving [times]		
								Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
<b>Parmesan chicken</b>	Pressure cooker	1.350	0.748	0.554	0.565	0.584	0.554	19%	20%	18%	5.4	5.0	5.7	4.4	4.0	4.7
	Pressure cooker	1.350	0.751	0.556												
	Pressure cooker	1.350	0.788	0.584												
	Oven	1.360	4.200	3.088	3.047	3.159	2.894									
	Oven	1.410	4.080	2.894												
	Oven	1.380	4.360	3.159												
<b>Cajun Chicken</b>	Air fryer	1.650	0.727	0.441	0.443	0.451	0.436	16%	18%	15%	6.2	5.7	6.7	5.2	4.7	5.7
	Air fryer	1.628	0.735	0.451												
	Air fryer	1.600	0.698	0.436												
	Oven	1.560	4.000	2.564	2.744	2.935	2.564									
	Oven	1.610	4.400	2.733												
	Oven	1.540	4.520	2.935												

<sup>7</sup> Total energy consumption was calculated following [Frankowska et al. \(2020\)](#), using the timing of the oven cooking, which includes preheating the oven and cooking time, and the manufacturer information. The oven used is a Lamona 3210 with a power of 2400W

## References

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[https://www.researchgate.net/publication/342123095\\_Cooking\\_as\\_part\\_of\\_a\\_global\\_sustainable\\_food\\_system\\_-\\_a\\_6\\_country\\_pilot\\_survey](https://www.researchgate.net/publication/342123095_Cooking_as_part_of_a_global_sustainable_food_system_-_a_6_country_pilot_survey)

## Appendix

### A1. Oven recipe for Cajun chicken

#### INGREDIENTS

1.6 kg whole free range chicken  
2 tbsp cajun spice  
Salt & pepper  
Cooking spray oil

#### INSTRUCTIONS

1. Take chicken out of the fridge 1 hour before cooking to allow it to come to room temperature. Temperature in room should be between 20-22°C.
2. Heat oven to 190°C/fan 170°C/gas 5.
3. Pat dry the chicken and combine the cajun spices with the salt and pepper, then rub the spices all over the chicken
4. Spray the chicken with cooking spray then place the whole chicken in the oven.
5. Cook for 1 hour, turning the chicken halfway through cooking.
6. Turn the chicken over again so that it is breast-side up and cook for a further 20 minutes.
7. When the cooking program has finished, use a meat thermometer to check the internal temperature of the chicken is at 75°C. If it isn't quite to temperature, put it back in the oven for another 10-15 minutes.
8. Let the roast chicken rest for 5-10 minutes before serving.

### A2. Oven recipe for rosemary and parmesan chicken

#### INGREDIENTS

2 lemons  
3 tsp salt plus more to taste  
3 tsp black pepper  
2 tsp rosemary chopped  
6 rosemary sprigs  
2 tsp red pepper flakes plus more for serving optional  
1 whole free range chicken about 1.4kg  
extra-virgin olive oil for drizzling  
45 g parmesan finely grated  
900ml chicken stock



## INSTRUCTIONS

1. Take chicken out of the fridge 1 hour before cooking to allow it to come to room temperature. Temperature in room should be between 20-22°C.
2. Heat oven to 190°C/fan 170°C/gas 5.
3. Finely grate 2 teaspoons of zest from the lemons and place into a small bowl. (Save the zested lemon for the drippings.)
4. Stir in the salt, pepper, chopped rosemary and red-pepper flakes. Season the chicken inside and out with salt mixture and set aside. Stuff cavity of chicken with 2 rosemary springs.
5. Place the chicken breast-side down into a deep ovenproof dish with the stock, and 2 of the rosemary springs.
6. Allow to cook for around 1 hour.
7. Remove from the oven, and using tongs take the chicken out of the dish and drain the water.
8. Transfer to a different clean dry dish, drizzle the chicken with the olive oil and place it back into the oven.
9. Increase temperature to 200°C/fan 180°C/gas 6 for 25 minutes. In the middle of the cooking process sprinkle the chicken with the parmesan cheese. Continue roasting.
10. When cooking is complete the internal temperature should reach 75°C. Let the chicken rest for 5 to 10 minutes then squeeze juice from one of the zested lemons over the chicken.

### A3. Vortex recipe for cajun chicken

#### INGREDIENTS

- 1.6 kg whole chicken
- 2 tbsp cajun spice
- Salt & pepper

#### INSTRUCTIONS

1. Pat dry the chicken and combine the cajun spices with the salt and pepper, then rub the spices all over the chicken
2. Select Air Fry and adjust the temperature to 180°C and the time 60 minutes. Preheat Vortex until display indicates Add Food.
3. Spray the air fryer with cooking spray, then place the whole chicken inside.
4. When prompted to Turn Food, turn the chicken over and continue cooking.
5. With 10 minutes left on the timer, open the tray and turn the chicken over again.
6. When the cooking program has finished, use a meat thermometer to check the internal temperature of the chicken is at 75°C. If it isn't quite to temperature put back in the air fryer for a few more minutes.
7. Let the Air Fryer Roast Chicken rest for 5-10 minutes before serving.

## A4. Pro-crisp recipe for rosemary and parmesan chicken

### INGREDIENTS

2 lemons  
3 tsp salt plus more to taste  
3 tsp black pepper  
2 tsp rosemary chopped  
6 rosemary sprigs  
2 tsp red pepper flakes plus more for serving optional  
1 whole chicken about 1.4kg  
extra-virgin olive oil for drizzling  
45 g parmesan finely grated  
900ml chicken stock

### INSTRUCTIONS

1. Finely grate 2 teaspoons of zest from the lemons and place into a small bowl. (Save the zested lemon for the drippings.)
2. Stir in the salt, pepper, chopped rosemary and red-pepper flakes. Season the chicken inside and out with salt mixture and set aside. Stuff cavity of chicken with 2 rosemary sprigs.
3. Place the chicken breast-side down into the inner pot and the stock, and 2 of the rosemary sprigs.
4. Select Pressure Cook, and set to High pressure for 20 minutes, followed by Quick Pressure Release.
5. Remove the lid, and using tongs take the chicken out of the inner pot and drain the water.
6. Making sure that your inner pot is dry, place the air fryer basket (or trivet) into the pot, drizzle the chicken with the olive oil and place it into the basket.
7. Using the Air fryer Lid select Roast at 200°C for 25 minutes. In the middle of the cooking process sprinkle the chicken with the parmesan cheese. Continue roasting.
8. When cooking is complete the internal temperature should reach 75°C. Let the chicken rest for 5 to 10 minutes then squeeze juice from one of the zested lemons over the chicken.