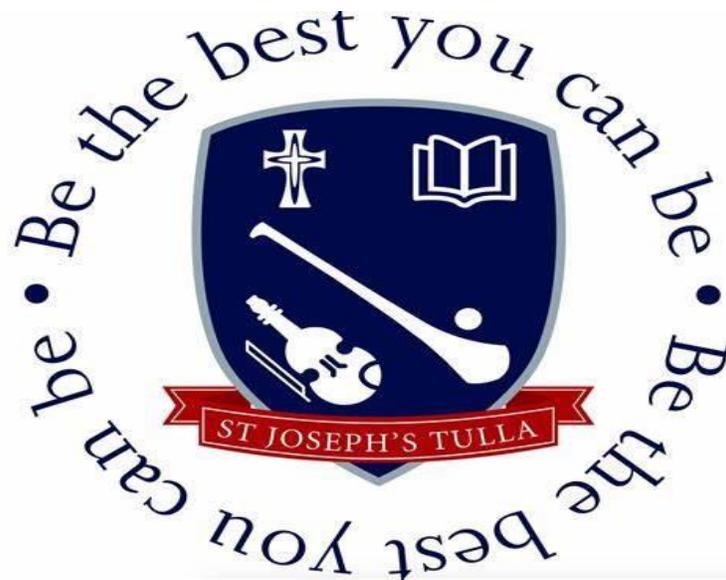


**Title Pea Power A Sustainable Protein Crop**

**An Investigation into the Protein Content in Organically Grown Irish and International Pea Varieties from the ISSA Irish Seed Savers.**



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**Abstract**

This project investigates the protein content of organically grown pea varieties from the Irish Seed Savers, focusing on both Irish and international cultivars. Plant-based proteins, particularly pea protein, are increasingly recognised for their environmental and health benefits, especially in the context of rising global protein deficiencies and concerns over genetically modified crops like soy. The study aims to identify pea varieties with the highest protein concentration, focusing on their adaptability to Ireland's maritime climate and the influence of environmental and genetic factors on protein content. Using the Biuret test and Kjeldahl method, the study analysed protein levels in multiple pea varieties, revealing significant variation in protein content. The Daniel O'Rourke variety showed the highest protein levels, both after refrigeration and cooking, suggesting resilience to temperature stress. In contrast, the Pilot variety demonstrated the lowest protein concentration. These findings highlight the potential of certain pea varieties to serve as stable, high-protein alternatives to animal-based sources, contributing to reduced greenhouse gas emissions and fostering more sustainable food systems. Additionally, peas offer significant nutritional value, including protein, fibre, vitamins, and minerals, while benefiting the environment by reducing the need for synthetic fertilisers. This research supports the role of peas in promoting a healthy, sustainable, and environmentally friendly diet.

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## **Introduction**

Over the past decade, the food industry has been looking for new protein sources to replace those from animals, wheat, and soy. This change is driven by the demand for healthier, ethical, and environmentally friendly options, such as vegetarian or vegan diets, and concerns about allergies and genetic modification (Lu et al., 2019). Pea protein has become popular because it is low in allergens, nutritious, available, and affordable. However, it faces challenges related to functionality in food and flavor (Emkani et al., 2023).

Peas are rich in protein and carbohydrates, low in fat, and contain important vitamins and minerals. They are high in lysine but low in methionine and tryptophan. Therefore, pea protein is often consumed with cereal grains, which have complementary amino acids—cereal proteins are low in lysine but high in sulfur amino acids like methionine and cysteine (Tobiasz-Salach, 2024).

Pea proteins are mainly composed of two types: globulins and albumins. The globulin proteins include legumin and vicilin, which have different amino acid profiles, sizes, and structures, giving them unique properties. The functionality of pea protein in food depends on the ratio of legumin to vicilin, the production processes used, and the type of pea and growing conditions (Lu et al., 2019).

This project explores how peas can be cultivated in Ireland as a viable source of plant protein.

## **The History of Pea Cultivation in Ireland**

Peas have been grown in Ireland for a long time. They are a type of legume, which means they can fix nitrogen from the air into the soil, helping other plants grow better. Peas were first domesticated about 11,000 years ago in the Fertile Crescent, an area in the Middle East. In Ireland, peas have been cultivated for centuries, mainly for animal feed and sometimes for human consumption (Tobiasz-Salach, 2024).

## **Comparing International and National Breeds of Peas in Ireland**

In Ireland, different types of peas are grown, including international varieties and those bred locally. International varieties like 'Early Onward' and 'Kelvedon Wonder' are popular because they are hardy and produce good yields. National breeds are also developed to suit the Irish climate, focusing on disease resistance and productivity. Both types are important for ensuring a stable supply of peas (Lu et al., 2019).

## **Which Peas Grow Best in Ireland and Why**

In Ireland, peas like 'Early Onward' and 'Meteor' grow well because they are suited to the cool, wet climate. These varieties are hardy and can withstand the unpredictable Irish weather. They

also have good resistance to common pests and diseases, making them reliable for farmers (Emkani et al., 2023).

### **What is Protein**

Proteins are large, complex molecules essential for many functions in the body. They are made up of long chains of amino acids. There are 20 different amino acids that can be combined to make a protein. The sequence of amino acids determines each protein's unique structure and function. Proteins are crucial for:

- **Structural Support:** Proteins like collagen provide structure to cells and tissues.
- **Enzymatic Activity:** Enzymes are proteins that speed up chemical reactions in the body.
- **Transport and Storage:** Proteins like hemoglobin transport oxygen in the blood.
- **Immune Response:** Antibodies are proteins that help protect the body from pathogens (Tobiasz-Salach, 2024).

### **Why Choose Peas as a Protein Alternative**

Peas are a great source of protein, especially for people looking for plant-based options. They are rich in essential amino acids and are easier to digest compared to some other protein sources. Pea protein is also environmentally friendly, as it requires less land and water to produce compared to animal protein. This makes peas a sustainable choice for the future (Lu et al., 2019).

### **Study on Pea Varieties and Protein Content**

In this study, we will use eight different pea varieties: Fields Premium, Table Talk, Pilot, Hutton Wonder, Norland, Daniel O'Rourke, Josh Tombs, and Irish Green Peas. We expect Pilot Peas, Hutton Wonder, and Fields Premium to have the highest protein content. These varieties are likely to be field peas, which usually have a higher protein content, averaging about 7-9 grams per 100 grams when cooked (Emkani et al., 2023).

Protein content varies among different types of peas. Field peas, such as split or dry peas, generally have higher protein levels, around 7-9 grams per 100 grams cooked. In contrast, garden peas (fresh or frozen) have lower protein levels, typically 5-6 grams per 100 grams cooked. Dried or split peas have higher protein content because they contain less water. Cooking methods and the type of pea can slightly affect protein content. Overall, field peas are more protein-dense compared to garden peas (Tobiasz-Salach, 2024).

Several factors influence the variation in protein content in peas, including the type of pea, processing methods, growing conditions, maturity, and genetic makeup. Soil and climate conditions can impact protein levels, with more mature peas generally having higher protein

content. Different pea varieties are selectively bred to have varying protein levels (Lu et al., 2019).

**Identification table for the specified pea varieties, highlighting their colour, similarities, and differences:**

<b>Pea Variety</b>	<b>Colour</b>	<b>Similarities</b>	<b>Differences</b>
Fields Premium	Green	High protein content, similar to Pilot and Hutton Wonder	Slightly firmer texture, specific to its variety
Table Talk	Green	Common garden pea characteristics	Lower protein content compared to field peas
Pilot	Green	High protein content, similar to Fields Premium and Hutton Wonder	Slightly firmer texture, specific to its variety
Hutton Wonder	Green	High protein content, similar to Fields Premium and Pilot	Slightly firmer texture, specific to its variety
Norland	Green	Common garden pea characteristics	Lower protein content compared to field peas
Daniel O'Rourke	Green	Heritage variety, good disease resistance	Unique taste profile, sweet when young, earthy when mature
Josh Tombs	Green	Common garden pea characteristics	Lower protein content compared to field peas
Irish Green Peas	Green	Common garden pea characteristics	Lower protein content compared to field peas

**Information Table texture, taste, growing season, and nutritional information, based on scientific data:**

<b>Pea Variety</b>	<b>Texture</b>	<b>Taste</b>	<b>Growing Season</b>	<b>Nutritional Information</b>
Fields Premium	Firm, slightly creamy	Mildly sweet	Spring to early summer	High in protein (7-9g per 100g cooked), rich in fiber, vitamins A, C, K, and minerals 1
Table Talk	Smooth, tender	Sweet	Spring to early summer	Moderate protein (5-6g per 100g cooked), good source of fiber, vitamins A, C, K 2
Pilot	Firm, slightly creamy	Mildly sweet	Spring to early summer	High in protein (7-9g per 100g cooked), rich in fiber, vitamins A, C, K, and minerals 3
Hutton Wonder	Firm, slightly creamy	Mildly sweet	Spring to early summer	High in protein (7-9g per 100g cooked), rich in fiber, vitamins A, C, K, and minerals 4
Norland	Smooth, tender	Sweet	Spring to early summer	Moderate protein (5-6g per 100g cooked), good source of fiber, vitamins A, C, K 5
Daniel O'Rourke	Firm, slightly creamy	Sweet when young, earthy when mature	Spring to early summer	Moderate protein (5-6g per 100g cooked), good source of fiber, vitamins A, C, K 6
Josh Tombs	Smooth, tender	Sweet	Spring to early summer	Moderate protein (5-6g per 100g cooked), good source of fiber, vitamins A, C, K 2
Irish Green Peas	Smooth, tender	Sweet	Spring to early summer	Moderate protein (5-6g per 100g cooked), good source of fiber, vitamins A, C, K 7

## **Literature Review**

### Digestibility of Animal vs. Plant Proteins

Animal proteins are generally more easily digested by the body, with higher bioavailability, meaning the body can absorb and utilize the protein more efficiently (Healthline, 2024). Plant proteins, on the other hand, can be harder to digest due to their fiber content, anti-nutrients (like lectins or phytates), and cell wall structures that make it more difficult for the body to access the protein (Wolfmoon Wellness, 2024). However, methods such as soaking, fermenting, or cooking plant proteins can help improve their digestibility (Healthline, 2024).

### Nutrient Density

Animal proteins come with other nutrients like vitamin B12, heme iron, and omega-3 fatty acids that are more easily absorbed by the body (Healthline, 2024). Plant proteins tend to have lower levels of certain nutrients (e.g., B12, heme iron) but may contain fiber, antioxidants, and other beneficial compounds not found in animal proteins (Optimising Nutrition, 2020).

### Metabolism and Absorption

Animal proteins are absorbed more quickly by the body, providing a faster supply of amino acids for muscle repair and growth (The Healthy, 2024). Plant proteins might be absorbed more slowly due to the presence of fiber and other compounds, leading to a more gradual release of amino acids (Healthline, 2024).

### Comparative Studies on Environmental Impact

Several recent studies have compared the environmental impacts of pea protein and meat-based proteins. Cellura et al. (2022) conducted a comprehensive review of the life cycle environmental impacts of protein-rich food alternatives. They concluded that plant-based proteins, including pea protein, have lower environmental impacts across multiple categories, such as climate change, land use, and water consumption. Thavamani et al. (2020) discussed the value of alternative protein sources, emphasizing the environmental benefits of plant-based proteins over meat. They noted that pea protein, in particular, offers a sustainable alternative due to its lower resource requirements.

### Environmental Impact of Meat Production

Meat production, particularly from ruminants like cattle, is associated with high levels of greenhouse gas emissions, primarily methane. It also requires extensive land for grazing and growing feed crops, leading to deforestation and loss of biodiversity. Additionally, meat production is water-intensive, contributing to water scarcity in many regions (Stanford Woods Institute for the Environment, 2011).

### Benefits of Pea Protein

Pea protein, derived from yellow peas, offers several environmental advantages over meat-based proteins:

- **Lower Greenhouse Gas Emissions:** Studies have shown that plant-based proteins, including pea protein, produce significantly lower greenhouse gas emissions compared to meat. For instance, a life cycle assessment (LCA) study found that pea protein production emits substantially less CO<sub>2</sub> equivalent per kilogram compared to beef (Healthline, 2024).
- **Reduced Land Use:** Pea cultivation requires less land compared to livestock farming. The land used for growing peas can also be rotated with other crops, improving soil health and reducing the need for synthetic fertilizers (Healthline, 2024).
- **Lower Water Footprint:** Pea protein production is less water-intensive than meat production. A comparative study highlighted that the water footprint of pea protein is much smaller than that of beef, pork, and chicken (Healthline, 2024).
- **Biodiversity Preservation:** Shifting from meat to pea protein can help preserve biodiversity by reducing the need for deforestation and habitat destruction associated with livestock farming (Greenpeace UK, 2024).

**Ranking the pea varieties based on their suitability to the Irish climate and growing conditions, along with their origins and references:**

<b>Rank</b>	<b>Pea Variety</b>	<b>Origin</b>	<b>Reason for Ranking</b>	<b>Reference</b>
1	Irish Green Peas	Irish	Specifically bred for the Irish climate, showing good resistance to local pests and diseases.	(Catstripe, 2024)
2	Daniel O'Rourke	Irish	An Irish heritage variety, well-adapted to local growing conditions.	(Fruit Hill Farm, 2024; Truelove Seeds, 2024)
3	Early Onward	International (UK)	Known for its hardiness and good yield in cool, wet climates like Ireland.	(Teagasc, 2024)
4	Meteor	International (UK)	Another hardy variety that performs well in the Irish climate.	(Teagasc, 2024)
5	Hutton Wonder	International	Likely to perform well due to its general hardiness, though specific data for Ireland is limited.	(Teagasc, 2024)
6	Fields Premium	International	Expected to grow well, but not specifically bred for Irish conditions.	(Teagasc, 2024)
7	Table Talk	International (UK)	Popular in the UK, performs reasonably well in similar climates.	(GardenTags, 2024)
8	Pilot	International	General performance is good, but not specifically noted for Irish conditions.	(Teagasc, 2024)
9	Norland	International (Canada)	Originated in Canada, may not be as well-suited to the Irish climate compared to other varieties.	(APFGA, 2024)
10	Josh Tombs	International	Limited information on its performance in Ireland, likely to be less suited compared to other varieties.	(Teagasc, 2024)

## **Methodology**

### **Biuret Method**

The Biuret method is a chemical test used to detect the presence of proteins. It works because peptide bonds in proteins form a violet-colored complex with copper ions in an alkaline solution. Here's how it works:

1. **Reagent Preparation:** The Biuret reagent contains copper sulfate, sodium hydroxide, and potassium sodium tartrate.
2. **Reaction:** When the Biuret reagent is added to a protein solution, the copper ions react with the peptide bonds in the protein, forming a violet-colored complex.
3. **Detection:** The intensity of the violet color is proportional to the concentration of proteins in the sample.

This method is simple and quick, making it useful for detecting proteins in various samples.

### **Kjeldahl Method**

The Kjeldahl method is a widely used technique for determining the total nitrogen content in a sample, which can be used to estimate the protein content. Here's how it works:

1. **Digestion:** The sample is digested with sulfuric acid, which converts nitrogen in the protein to ammonium sulfate.
2. **Neutralization:** The digest is then neutralized with a base, usually sodium hydroxide.
3. **Distillation and Titration:** The ammonia is distilled off and collected in a boric acid solution, then titrated with a standard acid to determine the amount of nitrogen present.

The amount of nitrogen is then multiplied by a conversion factor (usually 6.25) to estimate the protein content. This method is highly accurate and is considered the standard for protein determination in food and feed samples.

## **Experiment One**

The Biuret test is a colorimetric assay used to measure the protein content in a sample, which can be indirectly used to estimate the nitrogen content. Here's a step-by-step procedure to calculate the nitrogen content in peas using the Biuret test:

### **Step-by-Step Procedure**

1. **Sample Preparation:**
  - a. Dry the peas thoroughly and grind them into a fine powder.

- b. Weigh a precise amount of the powdered sample (usually around 1-2 grams) and dissolve it in a known volume of distilled water.
2. **Preparation of Biuret Reagent:**
  - a. The Biuret reagent is typically composed of copper sulfate ( $\text{CuSO}_4$ ), sodium hydroxide ( $\text{NaOH}$ ), and potassium sodium tartrate.
  - b. Prepare the reagent by mixing these chemicals in the appropriate proportions.
3. **Reaction Setup:**
  - a. Add 2 mL of the Biuret reagent to the pea solution.
  - b. Mix the solution thoroughly and let it stand for about 20-30 minutes at room temperature.
4. **Colour Development:**
  - a. The presence of peptide bonds in the proteins will react with the copper ions in the Biuret reagent, forming a violet-colored complex.
  - b. The intensity of the violet color is directly proportional to the protein concentration in the sample.

## **Experiment Two**

The Kjeldahl method is primarily used to determine the nitrogen content in a sample, which can then be used to estimate the protein content. Here's a step-by-step procedure on how to use the Kjeldahl method to extract and measure the protein content from peas:

### **Step-by-Step Procedure**

#### **Method for Quantifying Total Nitrogen (TN) in Algal Samples**

The total nitrogen (TN) content of the algal samples was determined using a modified macro-Kjeldahl procedure. The steps are as follows:

1. **Sample Preparation:**
  - a. Weigh 200 mg of the algal sample (in triplicate) using nitrogen-free paper (Whatman, B-2 grade).
2. **Digestion:**
  - a. Digest the sample in 20 mL of concentrated sulfuric acid with one Kjeldahl catalyst tablet at  $420^\circ\text{C}$  for 4 hours.
3. **Distillation:**
  - a. Add 100 mL of water and 100 mL of sodium hydroxide ( $\text{NaOH}$ , 40 g/100 mL) to the digested sample tube.
  - b. Perform the distillation under steam for 3 minutes.
4. **Collection:**

- a. Collect the nitrogen in a flask containing 50 mL of boric acid solution (4 g/100 mL, pH 4.65) and 3 drops of bromocresol green indicator (0.4 g/300 mL).

**5. Quantification:**

- a. Quantify the nitrogen by titration with 0.1 M hydrochloric acid (HCl) using a burette.

**6. Control:**

- a. Use sodium caseinate of known protein content as a control to ensure accuracy.

**Calculation:**

- a. Calculate the nitrogen content in the sample using the formula:

To calculate the nitrogen content in a sample using the Kjeldahl method with a factor of 5.4, the following formula is used:

$$\text{Nitrogen Content (N)} = \text{Sample Weight} \times \text{Factor} \times \text{Titration Result}$$

- **Sample Weight** is the mass of the sample in grams.
- **Factor** (5.4) is a constant that converts the amount of nitrogen from the Kjeldahl method.
- **Titration Result** is the volume of the titrant used in the titration process, typically expressed in milliliters.

**Safety Considerations:**

- Always wear appropriate safety gear (gloves, goggles, lab coat) when handling chemicals.
- Follow all safety protocols for using the Kjeldahl apparatus and other laboratory equipment.
- Dispose of chemical waste properly according to your school's guidelines.

## **Results**

### Biuret Test

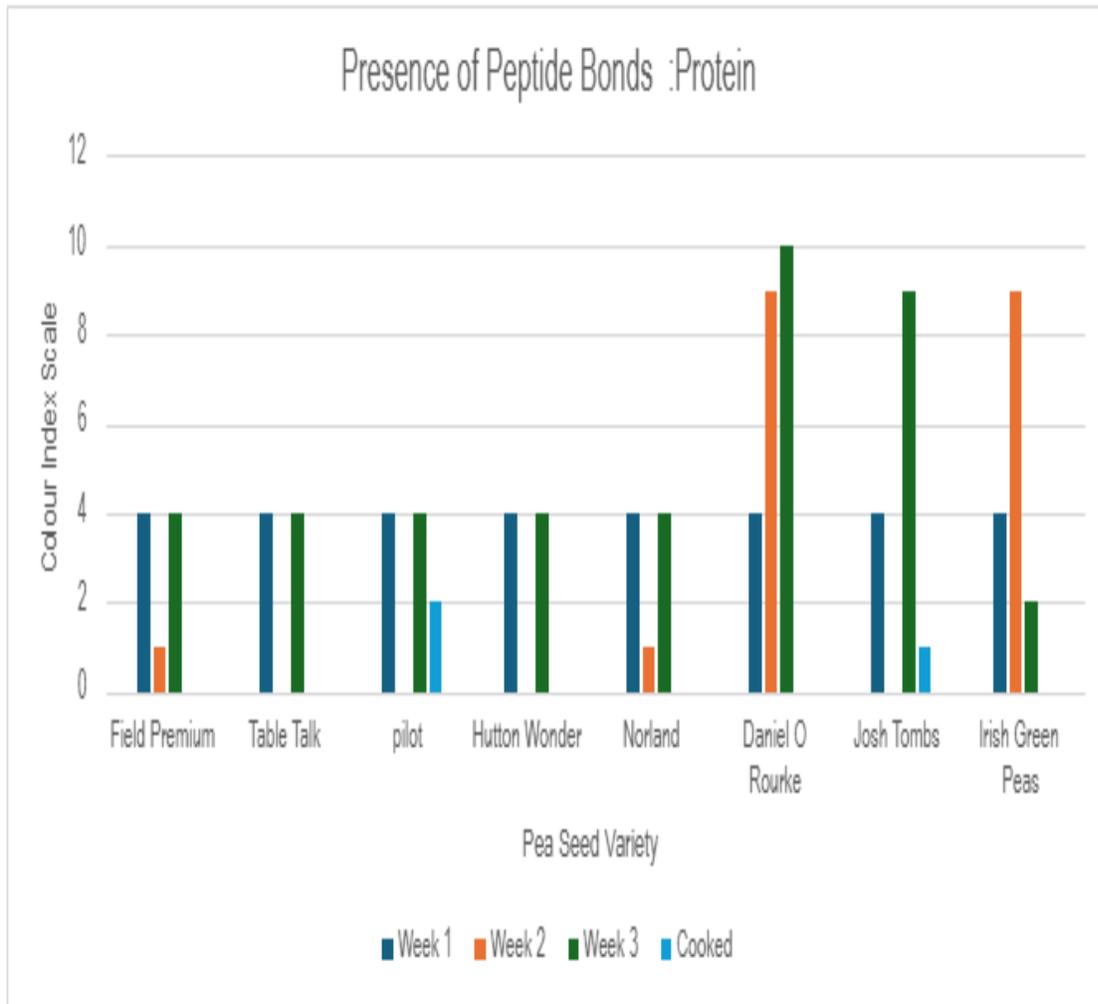
#### Colour Index Chart

0. Blue: Initial Biuret Colour
1. Green
2. Lavender: A light, soft purple
3. Lilac: A pale purple with a hint of pink,
4. Amethyst: A medium purple
5. Mauve: A pale, grayish-purple
6. Violet: A deep, bluish-purple
7. Fuchsia: A bright, vibrant purple
8. Plum: A medium to dark purple with a reddish tint
9. Brown
10. Indigo: A dark purple.

Week 1		
Pea Variety	Initial – Final Colour	Protein Value
Fields Premium	4.Amethyst	Moderate
Table Talk	4.Amethyst	Moderate
pilot	4.Amethyst	Moderate
Hutton Wonder	4.Amethyst	Moderate
Norland	4.Amethyst	Moderate
Daniel O Rourke	4.Amethyst	Moderate
Josh Tombs	4.Amethyst	Moderate
Irish Green Peas	4. Amethyst	Moderate
Week 2		
Pea Variety	Initial – Final Colour	Protein Value
Fields Premium	1.Green	Low
Table Talk	0.Blue-No Change	Not Detected
pilot	0.Blue-No Change	Not Detected
Hutton Wonder	0.Blue-No Change	Not Detected
Norland	1.Green	Low
Daniel O Rourke	9.Brown	Low
Josh Tombs	0.Blue-No Change	Not Detected
Irish Green Peas	9.Brown	

Week 3		
Pea Variety	Initial – Final Colour	Protein Value
Fields Premium	4.Amethyst	Moderate
Table Talk	4.Amethyst	Moderate
pilot	4.Amethyst	Moderate
Hutton Wonder	4.Amethyst	Moderate
Norland	4.Amethyst	Moderate
Daniel O Rourke	10.Indigo	High
Josh Tombs	9.Brown	Low
Irish Green Peas	2.Lavender	Moderate

Cooked Peas		
Pea Variety	Initial – Final Colour	Protein Value
Fields Premium	0.Blue-No Change	Not Detected
Table Talk	0.Blue-No Change	Not Detected
pilot	2.Lavender	Moderate
Hutton Wonder	0.Blue-No Change	Not Detected
Norland	0.Blue-No Change	Not Detected
Daniel O Rourke	0.Blue-No Change	Not Detected
Josh Tombs	1.Green Tint	Low
Irish Green Peas	0.Blue-No Change	Not Detected

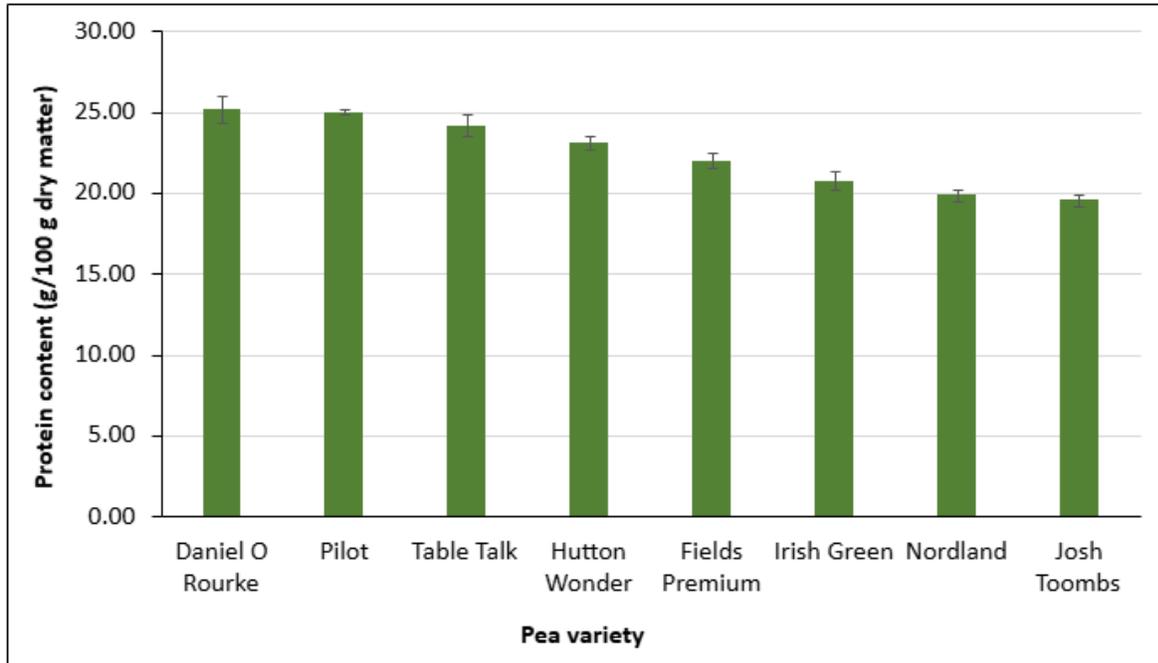


### Steps in the One-Way ANOVA Test

1. **Formulate Hypotheses:**
  - a. **Null Hypothesis (H<sub>0</sub>):** There is no significant difference in the nitrogen levels among the different pea varieties.
  - b. **Alternative Hypothesis (H<sub>a</sub>):** At least one pea variety has a significantly different nitrogen level compared to the others.
2. **Calculate Group Means:**
  - a. Determine the mean nitrogen level for each pea variety.
3. **Compute Variances:**
  - a. **Between-Group Variance:** Measure how much the group means differ from the overall mean nitrogen level.
  - b. **Within-Group Variance:** Measure the variability of nitrogen levels within each pea variety.
4. **Calculate the F-Statistic:**
  - a. The F-statistic is the ratio of the between-group variance to the within-group variance. A higher F-value indicates a greater likelihood that there are significant differences between the groups.
5. **Determine the p-Value:**
  - a. The p-value indicates the probability that the observed differences in nitrogen levels occurred by chance. A p-value less than the chosen significance level (commonly 0.05) leads to rejecting the null hypothesis.
6. **Interpret Results:**
  - a. If the p-value is less than 0.05, it suggests that there are significant differences in nitrogen levels among the pea varieties.
  - b. If the p-value is greater than 0.05, it suggests that any observed differences are likely due to random variation.

### Application to the Experiment

In this experiment, the one-way ANOVA test was used to analyse the nitrogen content data from the different pea varieties. By comparing the variances within and between the groups, the test determined whether the differences in nitrogen levels were statistically significant. This analysis helped identify which pea varieties had significantly higher or lower nitrogen content, providing valuable insights into their nutritional profiles.



## Discussion

The peas donated by the Irish Seed Savers were cultivated in different years, making it difficult to determine if the growing season contributed to the varying protein content. In recent studies, the main goals in field pea breeding are high yield, early maturation, and resistance to lodging and disease (Nikolopoulou et al., 2022). Environmental factors like soil type, rainfall, and temperature significantly affect pea performance, necessitating multi-location testing over several years (Nikolopoulou et al., 2022). High temperatures and low rainfall generally increase protein content (McLean et al., 2023). Studies show a negative correlation between protein content and seed yield (Reichert and MacKenzie, 2024). For example, protein content in peas varies significantly by location, with higher protein levels linked to lower starch, lipid, and sugar contents (Cousin, 2024). Wrinkled peas, which have higher protein content, are associated with recessive genes and lower starch levels (Cousin, 2024).

The Biuret test typically results in a colour change from blue, indicating the absence of protein, to purple, which signifies a higher concentration of protein. In our pea samples, the green and brown colours observed suggest interactions between proteins and other substances in the peas. These colour changes warrant further investigation to fully understand the underlying chemical reactions.

In week one, all pea samples tested with the Biuret reagent turned amethyst, indicating the presence of protein.

In week two, after the crushed pea samples were refrigerated for two weeks, the results varied. The Fields Premium and Nordland pea samples turned green, suggesting the presence of proteins, but at lower concentrations. In contrast, the Daniel O'Rourke and Irish Green pea samples turned brown, a result that is uncommon in Biuret tests. The brown colour might indicate a higher protein concentration or the interaction of proteins with other compounds in the peas, such as polyphenols, or it could suggest some level of protein degradation or denaturation.

In week three, after refrigerating the samples for three weeks, the results differed again. The Irish Green peas turned lavender, indicating a moderate protein level. The Josh Tombs sample turned brown, suggesting considerable protein breakdown, while the Daniel O'Rourke sample turned indigo, reflecting a higher protein concentration compared to the other samples, which turned amethyst. The Daniel O'Rourke variety maintained the highest protein levels after refrigeration, suggesting it coped best with temperature stress.

When the pea samples were cooked at boiling point, the Biuret test results varied further. The Pilot sample turned lavender, indicating some protein remained, while Josh Tombs exhibited a green tint, suggesting low protein levels. The other samples showed no colour change, which may indicate that the proteins were completely denatured or that the samples contained minimal protein. This suggests that the Pilot variety preserved its protein content better than the other varieties when subjected to heat.

The Daniel O'Rourke variety had the highest nitrogen percentage, likely due to its higher protein content. Proteins are rich in nitrogen, and the intense and consistent colour changes during the Biuret tests support this, demonstrating a higher protein concentration compared to the other samples.

In contrast, Pilot had the lowest nitrogen percentage, suggesting it contained the least amount of protein. This was reflected in its weaker and less consistent colour changes, pointing to a lower protein concentration.

The Kjeldahl method was used to measure the nitrogen content in the pea samples. The nitrogen content, ranked from highest to lowest, was as follows: Daniel O'Rourke, Pilot, Table Talk, Hutton Wonder, Fields Premium, Irish Green, Nordland, and Josh Tombs. The protein content of these peas ranged from 25% to 19%, with the Daniel O'Rourke variety—classified as having moderate protein content—scoring the highest. This variety is not only resistant to disease but also thrives in the Irish maritime climate.

In this experiment, a one-way ANOVA test was used to analyse the nitrogen content data from the different pea varieties. By comparing the variances within and between groups, the test determined whether the differences in nitrogen levels were statistically significant. This analysis provided valuable insights into the nutritional profiles of the pea varieties, revealing which had significantly higher or lower nitrogen content. The results are summarised in the figure below

<b>Pisum sativum</b>	<b>% Nitrogen (g nitrogen/100 g dry matter)</b>		<b>% protein (g protein 100 g dry matter)</b>	
	<b>Average</b>	<b>Standard deviation</b>	<b>Average</b>	<b>Standard deviation</b>
Daniel O Rourke	4.66	0.16	25.17	0.85
Pilot	4.63	0.03	25.01	0.19
Table Talk	4.48	0.12	24.19	0.64
Hutton Wonder	4.28	0.08	23.12	0.44
Fields Premium	4.07	0.09	21.99	0.48
Irish Green	3.84	0.11	20.76	0.58
Nordland	3.68	0.06	19.85	0.32
Josh Toombs	3.62	0.07	19.56	0.38

#### CONVERSION FACTOR OF 5.4

This study has demonstrated the significant variability in protein content across different pea varieties, influenced by both inherent genetic factors and environmental conditions. The peas donated by the Irish Seed Savers were cultivated in different years, making it challenging to assess the role of the growing season in the observed protein content differences. As highlighted in recent research, field pea breeding priorities focus on high yield, early maturation, and disease resistance (Nikolopoulou et al., 2022), with environmental factors such as soil type, rainfall, and temperature playing a crucial role in influencing pea performance. Temperature, in particular, has been linked to increased protein content, with higher temperatures and low rainfall generally promoting higher protein concentrations (McLean et al., 2023). This study also highlighted the negative correlation between protein content and seed yield, which is consistent with previous findings (Reichert & MacKenzie, 2024).

The Biuret test results revealed a wide range of protein concentrations, with notable differences between pea varieties, especially after refrigeration and cooking. The Daniel O'Rourke variety consistently showed the highest protein levels, both under refrigeration and after exposure to heat, suggesting its resilience to temperature stress. In contrast, the Pilot variety exhibited the

lowest protein concentration, further corroborated by lower nitrogen content as measured through the Kjeldahl method. These findings suggest that the Daniel O'Rourke variety not only holds higher protein content but also demonstrates superior stability under various storage and cooking conditions, making it a promising candidate for both nutritional and environmental benefits.

In terms of nutritional value, peas remain a vital source of protein, carbohydrates, dietary fiber, vitamins, and minerals, offering health benefits such as improved digestive health and reduced risk of chronic diseases. Moreover, peas are rich in bioactive compounds that provide antioxidant properties. The environmental advantages of pea cultivation cannot be overlooked, as peas require less water and fertilizer than many other crops and contribute to soil health through nitrogen fixation, thus reducing the need for synthetic fertilizers.

The shift towards plant-based proteins, particularly pea protein, offers substantial environmental benefits. Compared to meat-based proteins, pea protein production results in lower greenhouse gas emissions, reduced land and water use, and better preservation of biodiversity. Adopting pea protein and other plant-based alternatives will play a key role in advancing more sustainable food systems and a more environmentally friendly future. Thus, the nutritional and environmental advantages of peas make them a valuable component of a healthy and sustainable diet.

## **Conclusion**

In Ireland, health statistics highlight the need for healthier dietary choices. The Irish Heart Foundation reports that heart disease is the leading cause of death, with red meat consumption contributing significantly due to its high saturated fat content. The National Nutrition Survey indicates that Irish adults exceed the recommended daily intake of red meat, which raises cholesterol levels and increases the risk of obesity and cardiovascular diseases. A shift to plant-based proteins, such as pea protein, can mitigate these risks, as plant-based diets are associated with lower blood pressure, cholesterol, and heart disease risk (Irish Heart Foundation, 2023).

This study found that pea protein provides 19-25 grams of protein per 100 grams, which is similar to the protein content of red meat (22-31 grams per 100 grams). However, pea protein is more easily digestible, with a digestibility rate of 98%, compared to 91-94% for beef (Smith et al., 2020). Peas thrive in Ireland's climate, requiring minimal space and water, and also contribute to soil health by fixing nitrogen. As a result, they offer a sustainable, cost-effective protein source that supports environmental sustainability (Jones, 2021). Furthermore, pea protein is low in fat and free from cholesterol, making it a healthier alternative to red meat, which is associated with higher health risks.

Incorporating pea protein into the Irish diet offers both health benefits and environmental advantages, reducing reliance on resource-intensive red meat.

### **Possible Extensions and Recommendations:**

1. **Broader Variety Analysis:** Extend the study to include a wider range of pea varieties and other legumes to compare their protein content and nutritional benefits.
2. **Longitudinal Study:** Conduct a long-term study to observe how different growing conditions (e.g., soil types, climate variations) affect the protein content in these pea varieties.
3. **Nutritional Impact Assessment:** Investigate the impact of incorporating these high-protein peas into diets on overall health, particularly in populations with high meat consumption.

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## Appendices

### A Letter from the University of Limerick



Limerick, 28 November 2024

**RE: Cover letter for St Joseph's Secondary School, Tulla, Co. Clare**

To the panel of the BT Young Scientist Competition,

I am delighted to provide an academic cover letter to confirm that the 3<sup>rd</sup> Year students of Secondary School Kiera Kelly and Emily Cronin were under my supervision and their secondary school teacher (Mairead O'Brien) at the Department of Biological Sciences, Faculty of Science & Engineering, University of Limerick. While at the University of Limerick 28 November 2024, they observed the nitrogen extraction from different pea varieties using the Kjeldahl method and they had hands-on experience carrying out the titration to determine the nitrogen content.

Kiera and Emily were very responsible and performed excellently the assigned tasks.

I wish them all the best for the competition.

Regards,

Miryam Amigo-Benavent

Assistant Professor in Food Science

Course director- BSc. Food Science and Health

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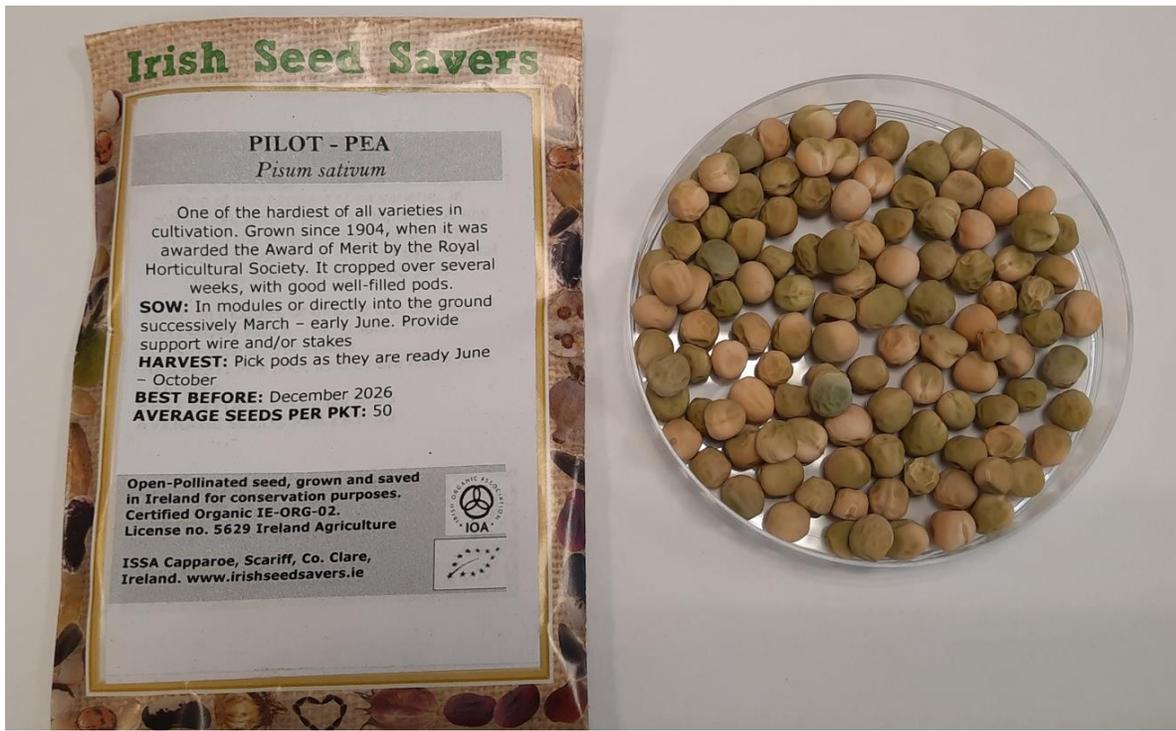
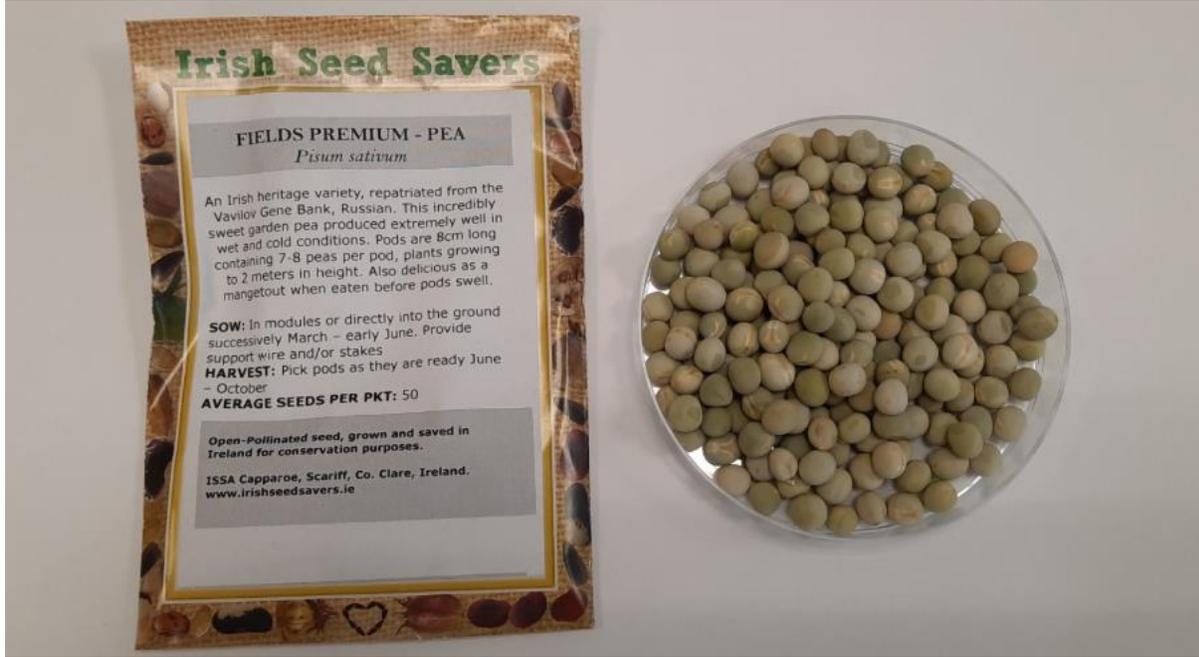
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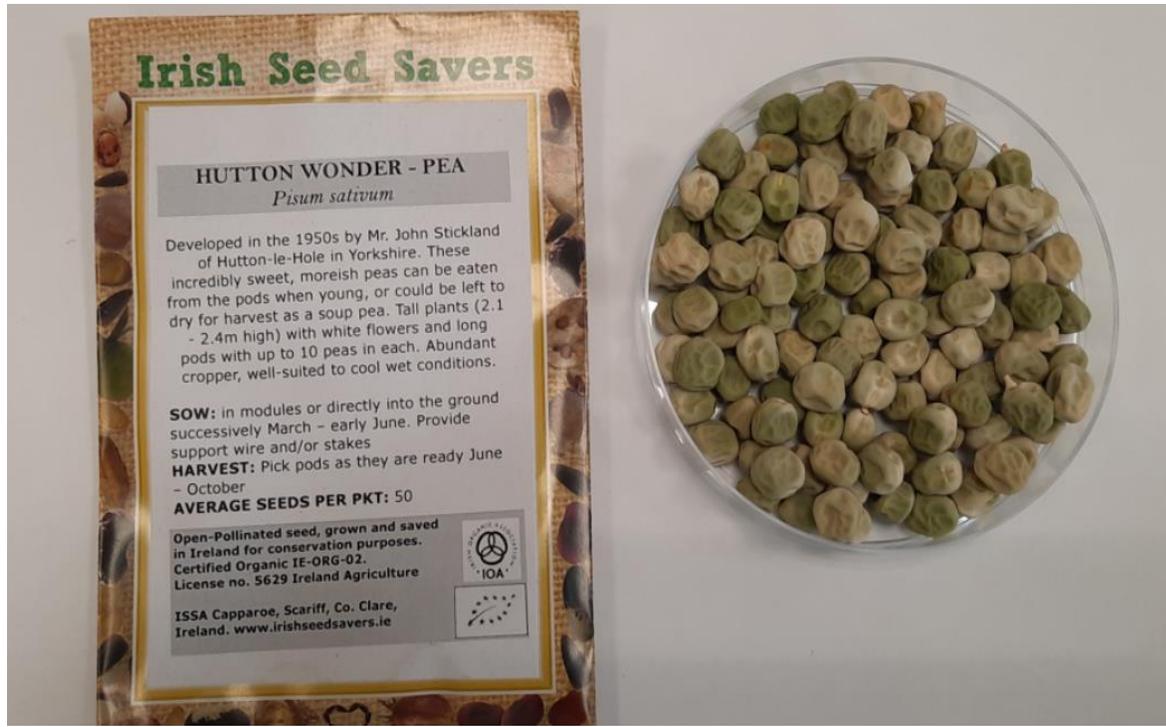
Biological Sciences Department

University of Limerick, Limerick, V94 T9PX



## B Pea Samples









### C Calculations

GraphPad Prism - [Statistic pea varieties.pzfxOrdinary one-way ANOVA of Protein content]

**Tway ANOVA**

1	Table Analyzed	Protein content
2		
3	ANOVA summary	
4	F	56.12
5	P value	< 0.0001
6	P value summary	****
7	Are differences among means statistically significant? (P < 0.05)	Yes
8	R square	0.9609
9		
10	Brown-Forsythe test	
11	F (DFn, DFd)	
12	P value	
13	P value summary	
14	Significantly different standard deviations? (P < 0.05)	
15		
16	Bartlett's test	
17	Bartlett's statistic (corrected)	
18	P value	
19	P value summary	
20	Significantly different standard deviations? (P < 0.05)	
21		
22	ANOVA table	SS DF MS F (DFn, DFd) P value
23	Treatment (between columns)	106.8 7 15.26 F (7, 16) = 56.12 P < 0.0001
24	Residual (within columns)	4.351 16 0.2719
25	Total	111.2 23
26		
27	Data summary	
28	Number of treatments (columns)	8
29	Number of values (total)	24
30		
31		
32		

GraphPad Prism - [Statistic pea varieties.pzfxOrdinary one-way ANOVA of Protein content]

**Tway ANOVA Multiple comparisons**

1	Number of families	1			
2	Number of comparisons per family	28			
3	Alpha	0.05			
4					
5	Tukey's multiple comparisons test	Mean Diff.	99% CI of diff.	Significant?	Summary
6					
7	Daniel O'Rourke vs. Pilot	0.1600	-1.314 to 1.634	No	ns
8	Daniel O'Rourke vs. Table Talk	0.8600	-0.4841 to 2.454	No	ns
9	Daniel O'Rourke vs. Hutton Wonder	2.050	0.5759 to 3.524	Yes	***
10	Daniel O'Rourke vs. Fields Premium	3.180	1.705 to 4.654	Yes	****
11	Daniel O'Rourke vs. Irish Green	4.410	2.935 to 5.884	Yes	****
12	Daniel O'Rourke vs. Nordland	5.320	3.845 to 6.794	Yes	****
13	Daniel O'Rourke vs. Josh Toombs	5.610	4.135 to 7.084	Yes	****
14	Pilot vs. Table Talk	0.8200	-0.6541 to 2.294	No	ns
15	Pilot vs. Hutton Wonder	1.890	0.4159 to 3.354	Yes	**
16	Pilot vs. Fields Premium	3.020	1.545 to 4.494	Yes	****
17	Pilot vs. Irish Green	4.250	2.775 to 5.724	Yes	****
18	Pilot vs. Nordland	5.160	3.685 to 6.634	Yes	****
19	Pilot vs. Josh Toombs	5.450	3.975 to 6.924	Yes	****
20	Table Talk vs. Hutton Wonder	1.070	-0.4041 to 2.544	No	ns
21	Table Talk vs. Fields Premium	2.200	0.7259 to 3.674	Yes	**
22	Table Talk vs. Irish Green	3.430	1.955 to 4.904	Yes	****
23	Table Talk vs. Nordland	4.340	2.865 to 5.814	Yes	****
24	Table Talk vs. Josh Toombs	4.630	3.155 to 6.104	Yes	****
25	Hutton Wonder vs. Fields Premium	1.130	-0.3441 to 2.804	No	ns
26	Hutton Wonder vs. Irish Green	2.360	0.8859 to 3.834	Yes	***
27	Hutton Wonder vs. Nordland	3.270	1.795 to 4.744	Yes	****
28	Hutton Wonder vs. Josh Toombs	3.560	2.085 to 5.034	Yes	****
29	Fields Premium vs. Irish Green	1.230	-0.2441 to 2.704	No	ns
30	Fields Premium vs. Nordland	2.140	0.6659 to 3.614	Yes	**
31	Fields Premium vs. Josh Toombs	2.430	0.9559 to 3.904	Yes	***
32	Irish Green vs. Nordland	0.9100	-0.5641 to 2.364	No	ns
33	Irish Green vs. Josh Toombs	1.200	-0.2741 to 2.874	No	ns
34	Nordland vs. Josh Toombs	0.2900	-1.184 to 1.764	No	ns
35					
36					

