Application of Data Science in Food Recipe Optimization

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Abstract.
Data science is very important for food product experiments, fusing data science technology into the field of modern food science can continuously optimize the formula or process, and improve product quality. This paper through potato chicken balls as a case, and aims to attract more artificial intelligence technology and food science combination, better serve the future development of the food industry.

Keywords: *Data science; Food; Recipe optimization;*

1   INTRODUCTION

Artificial intelligence (AI) is a popular definition and an earlier definition in this field. It was held by John McCarthy at the 1956 Dartmouth Conference So far: Artificial intelligence must make machines behave like human intelligence. In general, the definition of AI can be divided into four categories: machines "think like people", "act like people", "rational thinking", and "rational action", which should generally be understood as taking action, or the decision of action, rather than physical action. The research field, such as neural networks and machine learning, have also encountered difficulties, making the research of artificial intelligence a dilemma. The highs and lows of field research are alternating, and there are still people quite optimistic about the future of AI [2]. Linear regression family including simple linear regression and other more flexible models such as polynomial models are one of the essential AI models with great interpretability, explainability, and less computational resource needs.

With the rapid development of the food industry, the food industry is the largest industry, closely related to the lives of residents, and has an irreplaceable key position [3]. With the rapid economic development and the continuous improvement of residents' living standards, people have a growing demand for chicken food with high nutrition, low price and fresh and tender taste. Chicken balls have become a kind of healthy food because of their rich nutrition and simple preparation. However, the food production technology can not keep up with people's requirements for food quality, so how to improve the quality of chicken balls has attracted people's attention. By adding starch, the chicken balls have better quality and taste, which can better meet the needs of consumers. Potato is a kind of food and vegetable mixed type of vegetable, widely used in cooking, can make side dishes, salad, etc., and is also one of the five major crops in the world. It is known as the "underground apple" in France. Enjoy the title of "the second bread" in Europe and the United States. Potatoes are rich in vitamin A and vitamin C and minerals, high-quality starch content is about 16.5%, but also contains a lot of lignin, known as the "second bread" of human beings. It contains two times as many vitamins as carrots, three times as much as Chinese cabbage and four times as much as tomatoes, and its vitamin C content is the most common among vegetables. Experts have found that potatoes are the staple food in famous longevity villages like Bulgaria and Ecuador. Add to the chicken balls to make the nutrition more comprehensive. Wang Wenyong, Zhang Yinghui, and Yang Ming (2016) [4] found that reliability is an essential indicator of the applicability of minced chicken products, and various types of gel enhancers have improved their reliability and have high economic and practical value such as polysaccharides, starch, and protein. Konjac gum and xanthan gum intermixing can significantly increase the viscosity of the colloid, but also reduce the amount of gum used. The ratio of 7:3, with the total polysaccharide concentration of 1%, can form a solid gel. Therefore, the blended gum can not only be used as a thickening agent, but also as a gelling agent [1]. Zhang et al. (2000) studied the addition of auxiliary materials such as vegetable oil and vegetable protein

emulsifier in chicken meat, and the surface of meatballs made glossy, fluffy and delicious. [5]

Food science can be roughly divided into several branches, such as food chemistry, food engineering and food microbiology. Food Chemistry: it is a science that studies the chemical composition, structure, physical and chemical properties, nutrition and safety properties of food and their changes in the process of production, processing, storage and marketing and their impact on food quality and food safety from the chemical point of view and molecular level. It is aimed at improving food quality, developing new food resources, innovating food processing technology and storage and transportation technology, scientifically adjusting dietary structure, improving food packaging A discipline that lays a theoretical foundation for strengthening food quality control and improving the level of food raw material processing and comprehensive utilization. The research objects of food science are diverse, the raw materials are heterogeneous, and the process is complex. It is necessary to scientifically design experiments and analyze data in order to detect the internal regularity of things. Python is a high-level scripting language that combines interpretability, Bai translation, interactivity and object-oriented. It was originally designed to write automated scripts (shells). With the continuous updating of versions and the addition of new language functions, it is more and more used for the development of independent and large-scale projects. There are many places where Python can be used. Python is competent in data mining, scientific computing, image processing and artificial intelligence.

2 EXPERIMENT DESIGN AND ANALYSIS

Experimental materials. Skinless chicken leg, ginger, egg, cooking salt, mashed potatoes, white pepper, chicken essence, blended gum, vegetable oil.

Experimental apparatus and equipment. Meat grinder, Guangzhou Rong Yi Food Machinery Co. Mass Spectrometer, StableMicroSystems, UK; Electronic Scale, Shanghai Shangtian Precision Instruments Co., Ltd; Philips Mixer, Philips Investment Co.

2.1 Single-factor experimental design.

The frying temperature was controlled to 145℃, 150g of chicken minced meat, 10%, 15%, 20%, 25% and 30% of water were added to make several chicken meatballs with a diameter of 20mm by mixing and stirring, and the sensory scores were recorded for each group of experimental products.

Single-factor experiment on salt addition. The frying temperature was controlled to 145℃, 145g of chicken minced meat, salt added at 1%, 2%, 3%, 4%, and 5% were mixed and stirred to make several chicken meatballs with a diameter of 30mm, and sensory scores were made for each group of experimental products, and the results were recorded. Sensory evaluation is to judge the quality of the product according to the feeling of the human body, or to investigate the degree of liking. Sensory evaluation can directly show and reflect people's preference for food. However, everyone has different preference for food, and the results of sensory evaluation are biased to some extent. A bright, spacious and quiet place shall be selected to meet the standards of the sensory laboratory to the greatest extent according to the existing conditions. The inspection area shall be adjacent to the sample preparation area to facilitate the provision of samples. However, the two areas should be separated to reduce interference such as odor and noise, in order to avoid deviation of inspection results, evaluators are not allowed to pass through the preparation area when entering or leaving the inspection area. Temperature and relative humidity

The temperature of the inspection area should be controlled. If the relative humidity will affect the evaluation of the sample, the relative humidity in the test area should be controlled. Each sample shall be labeled with a tag number for random inspection. Each evaluator shall not contact and communicate with each other during each evaluation. Rinse with clean water before evaluation, and rinse with clean water after each evaluation. The scoring criteria are shown in Table 1.

Table 1. Sensory quality grading standard of potato chicken meatball.

Sensor evaluation (Score)	1 ~ 6	7 ~ 14	15 ~ 20
Color	Color is dark, color is too heavy	color light yellow, too light	Golden yellow color, evenly colored
Flavor	The chicken flavor is light, and the potato flavor is not obvious	There is a chicken flavor, and the potato flavor is not coordinated	There is a chicken flavor and the potato flavor in coordination

	Too hard or too soft, crumbly, no crispness, no toughness	A little soft or not easy to chew, a little crisp, more delicate	Crisp, smooth, crunchy, delicate, soft and hard
Taste	Too hard or too soft, crumbly, no crispness, no toughness	A little soft or not easy to chew, a little crisp, more delicate	Crisp, smooth, crunchy, delicate, soft and hard
Tissue Status	The section surface stomata are large and uneven	The cut surface is compact and uniform, and the pores is slightly larger	The section is compact and uniform, and the pores are small
Elasticity	Rupture by finger pressure	Finger pressure does not break	Finger pressure does not break

2.2 Single-factor experiment on mashed potatoes addition.

The frying temperature was controlled at 145℃, 145g of chicken minced meat was taken, and the amount of mashed potatoes added was 25%, 35%, 45%, 55%, and 65%, respectively. Several chicken meatballs with a diameter of 20mm were made by mixing and stirring, and the sensory scores of each group of experimental products were recorded.

2.3 Single-factor experiment on blended gum (konjac gum and xanthan gum intermixed in the ratio of 7:3) addition.

The frying temperature was controlled at 145℃, 145g of minced chicken meat was added with 0.3%, 0.4%, 0.5%, 0.6%, and 0.7% of blended gum, and several chicken meatballs with a diameter of 30mm were made by mixing and stirring. The sensory scores were recorded for each group of experimental products.

3   USING PYTHON FOR DATA SCIENCE

To analyze the collected data, we used NumPy 1.20.1 and Pandas 1.2.4 for data operation, scikit-learn 1.1.1 for regression analysis, and matplotlib 3.3.4 and seaborn 0.11.1 for data and model visualization on Python 3.8.8. We use data on water percentage as a demonstration in this section. Other data were analyzed following the same pipeline.

```python
# Import Necessary Libraries
import numpy as np
import pandas as pd

from sklearn.linear_model import LinearRegression

import matplotlib.pyplot as plt
import seaborn as sns
```

Figure 1: Packages used.

3.1 Data loading and exploratory data science

Now the most widely used data analysis language is python. Proficiency in a language has almost become a standard configuration for data scientists. Of course, these are just tools. Tools are the means to solve problems, not the end. Food experiments should have a tool that can be used for data analysis. Preferences vary from person to person. When selecting a tool, it is best to consider the flexibility and scalability of the tool.

After importing all necessary libraries, we read in data using Pandas and performed data exploratory analysis using matplotlib as shown below. We see that total score is largest when the water percentage is 20.

```
# Read data
data = pd.read_csv("data.csv")
data = data[:5]
```

```
# See the data
data.head()
```

	Water%	Color	Flavor	Taste	Tissue state	Elasticity	Total score
0	10.0	15.8	15.6	15.7	14.9	15.9	76.9
1	15.0	16.9	16.7	17.1	16.2	16.3	82.5
2	20.0	17.3	17.5	17.6	17.2	18.4	88.0
3	25.0	17.6	17.4	15.9	16.6	17.2	84.1
4	30.0	17.6	16.5	14.6	15.5	15.7	79.5

```
# EDA & Data visulization
sns.set()
x_name = data.columns[0]
ax = data.plot.bar(x=x_name, figsize=(10,6))
ax.set_ylabel('Score')
```

Text(0, 0.5, 'Score')
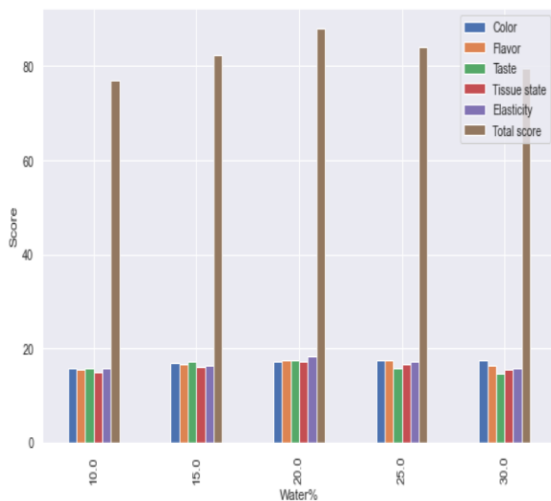
Figure 2: Exploratory data analysis.

3.2 Use polynomial regression to fit the relationship between water% and total score

Since it was observed that the relationship between water% and the total score was quadratic, we used polynomial regression to fit the model using sklearn, achieving R2 of 0.94, and the fitted model is $y = 49.68 + 3.54x - 0.09x^2$.

```
# Set Linear Regression to find relationship between Water% and Total Score
X = np.array([data[x_name], data[x_name]**2]).T
y = data['Total score']
reg = LinearRegression().fit(X, y)
R2 = reg.score(X, y)
```

```
# See R^2 and equation
print(f"R Square is {R2:.2f}.")
all_coefs = [reg.intercept_]+reg.coef_.tolist()
all_coefs_df = pd.DataFrame(all_coefs, index=['Intercept', x_name, x_name+'^2'], columns=['Coef'])
display(all_coefs_df)
```

R Square is 0.94.

	Coef
Intercept	49.680000
Water%	3.541714
Water%^2	-0.085143

```
# Model visualization
plt.figure(figsize=(10,6))
plt.plot(data[x_name], data['Total score'], marker='o')
pred_X = np.arange(data[x_name].min(), data[x_name].max(), 0.001)
pred_y = reg.predict(np.stack([pred_X, pred_X**2]).T)
equation = f"y={all_coefs[0]:.2f}+{all_coefs[1]:.2f}x{all_coefs[2]:.2f}x^2"
plt.plot(pred_X, pred_y, ls='--', label=equation)
plt.legend(loc=1)
plt.xlabel(x_name)
plt.ylabel('Total Score')
```
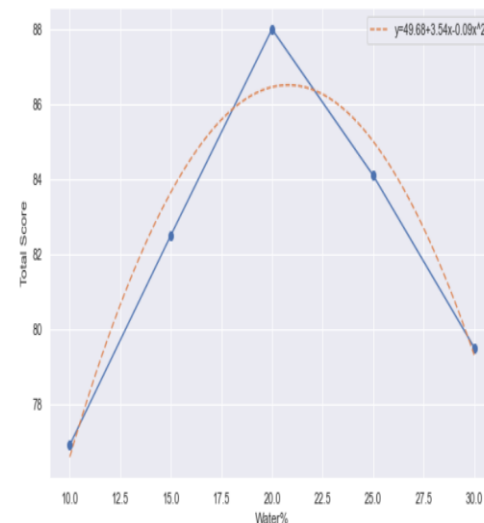
Text(0, 0.5, 'Total Score')

Figure 3 Polynomial model fitting.

3.2.1 Effect of water addition on sensory quality of chicken meatball

The role of water in food can be summarized into two categories: physical action and chemical action. Physical effects such as dissolution, emulsification, viscosity, texture formation, etc. Rinsing, dissolution, dispersion, infiltration, heat transfer, etc. Uniform heat transfer, help clean food materials and help them taste. Water in chicken balls can make raw materials and auxiliary materials mixed together to make potatoes full Moisture

absorption, which can promote the chicken balls to form a moderate soft and hard mouth in the subsequent process Feeling. On the other hand, the surface of the meatballs is smooth and delicate without a grainy texture. In this experiment, 10%, 15%, 20%, 25%, and 30% water were added to make five groups of crispy chicken meatballs with the constant addition of other ingredients, stirring speed and time, heating temperature and time, and the sensory evaluation test was conducted. The relationship between Water percentage and total score of water on sensory quality of chicken meatball is shown in Figure 3.

3.2.2 Effect of salt addition on sensory quality of chicken meatballs.

The role of salt in meat processing: seasoning. Adding salt can increase and improve food flavor. Among various uses of table salt, the function of seasoning in diet can not only remove fishy smell, freshness, greasiness, reduce or mask peculiar smell, balance J flavor, but also highlight the fresh flavor of raw materials. Salt changes the osmotic pressure of the solution, so that the solution in food is in a state of low osmotic solution. Salt has high permeability and can inhibit the growth of bacteria. When making meat balls and fish balls, salt is added to stir, which can improve the water consumption of raw materials and make the meat balls soft and juicy. "Salt has a dual effect on protein. When the concentration of salt is low, it can increase the solubility of salt soluble protein, Salt can affect the water holding capacity of chicken balls and improve the taste and texture of chicken balls. Salt can make chicken protein and fat have fresh flavor. In addition, salt can extract salt soluble protein from meat, promote its ability to combine water and fat, and reduce the loss of water from meat during heating treatment. In this experiment, five groups of crispy chicken meatballs were made with the addition of 1%, 2%, 3%, 4%, and 5% salt under the conditions of the constant addition of other ingredients, stirring speed and time, heating temperature, and time, and sensory evaluation tests were conducted. The specific results are shown in Figure 4.
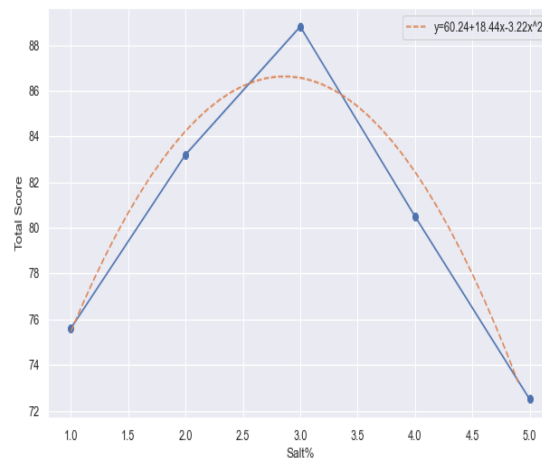
Figure 4: Effects of salt on sensory scores of chicken meatballs

3.2.3 Effect of mashed potatoes addition on sensory quality of chicken meatballs.

Potato is a kind of potato crop. It is a plant belonging to Solanaceae and Solanaceae. It is also an annual herb. Its tubers are edible. It is the fourth most important food crop in the world, second only to rice, wheat and corn. Potato is an important plant type for both food and vegetables in China. It has very high productivity and applicability, and has advantages that other plants do not have. Potatoes have high nutritional value and contain protein, vitamins and other substances, Mashed potatoes is a thickening agent, which is often used in the cooking process, and it can make the tissue state of meat products uniformly dense and elastic. In this experiment, 25%, 35%, 45%, 55%, and 65% salt were added to make five crispy chicken meatballs with the constant addition of other ingredients, stirring speed and time, heating temperature and time, and sensory evaluation tests were conducted. The specific results are shown in Figure 5.
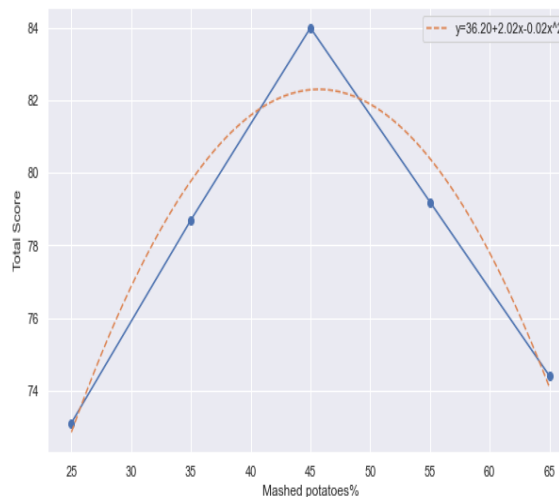
Figure 5: Effects of mashed potatoes on sensory scores of chicken meatballs

4. CONCLUSIONS

The country is based on the people, the people are based on food, food safety is the first, and safety is based on quality." food is an important material for human life activities. Especially after the epidemic, people have paid more attention to healthy and nutritious food, and food science has entered the public's field of vision. Since it became an independent discipline in the middle of the last century, food science has made great changes and progress in its coverage, research scale, research level, industrial application and social impact after decades of development. after entering the 21st century, international food science research has entered a stage of rapid development, and there have been some new changes in research directions and methods. Food science has a long history, its connotation is also very rich, and has been deeply rooted in people's daily diet life. Human survival is inseparable from healthy food, which is the basis of material contact between human and society, and plays a very important role in maintaining people's life activities. With the continuous development of society, people have a deeper understanding of food and pay more and more attention to their diet life. Once they eat improperly, they are easy to suffer from chronic diseases such as heart disease and diabetes, which pose a great threat to their health. China's food science research has made great progress, served the world's largest food industry system well, and became its strong strategic support and technical guarantee. The most proud thing is to ensure the food supply and food safety of the world's largest population.

Experimental design and data processing is based on the professional knowledge and practical experience of mathematical statistics theory, scientific design of experiments, and analysis of the experimental data, to reduce the number of experiments shorten the experiment cycle quickly find the optimal experimental scheme. Scientific and reasonable experimental design can achieve twice the result with half the effort, while rigorous and accurate data processing can help researchers find the internal laws of things from the chaotic data. A scientific and reasonable experiment design should: the number of experiments should be as few as possible; Easy to analyze and process test data; Satisfactory results can be obtained. Experimental design includes single factor experimental design and multi - factor experimental design. Python plays an increasingly important role in the field of science and engineering. Its excellent performance in data processing, scientific computing, mathematical modeling, data mining and data visualization makes Python widely used in academic research and engineering projects and effectively solves various data analysis problems. It can be predicted that Python will become the mainstream programming language in the field of science and Engineering in the future.

This topic is mainly aimed at the research on the influence of different potato additions on the quality of chicken balls. By searching the literature and analyzing the results of the optimal potato additions through the method of experimental design, the optimal potato additions are obtained, the results are as follows: a single factor experiment was designed and combined with the sensory evaluation criteria. The following conclusions were drawn: when 20% water, 3% salt, 45% mashed potato were added, the sensory evaluation score was the highest. which provides a scientific basis for the application of potato chicken balls processing technology and the production of chicken balls by reference modern enterprises.

ACKNOWLEDGMENTS

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