I. An Overview of Potato and Potato Chips

Values of Potatoes
Potato is an economic crop with high yield, strong adaptability, wide distribution, rich nutrient content and high economic value. It can be used as dishes, food, animal feed, or industrial raw materials. Potato tubers are rich in starch and extremely important nutrients for human body, such as proteins, carbohydrates, minerals, vitamins, etc. Potatoes are less fat content, but other nutrients are significantly higher than those of wheat, rice and maize. So potatoes are a low-calorie, high-protein nutritional food.

What is Potato Chips?
Potato chips are a convenience food which are made of fresh potatoes as raw material, then through cleaning, peeling, slicing and flavoring and other processes. Potato chips are popular in people for crispy, flavorful, nutritious, inexpensive and suitable for both young and old. After high temperature and short time frying, potato chips are quickly dehydrated. Compared with traditional processing method, such as frying, braising, it can effectively prevent the water-soluble nutrients losing in the processes. As a heat transfer medium, oil has such characteristics as insulation, dry, uniform heating and quickly heat transfer and has a good effect on the color and flavor of the product. We can also enhance nutrients in processing, further improve the nutritional value of potato chips.

II. The Flow Chart of Potato Chips Processing Line
1. **Material Selection:** Select fresh potatoes of high dry matter content, pure varieties, light eyes, regular shape, free from mildew rot, sprouting and insect infestations and other phenomena, 50~70mm in diameter.

2. **Cleaning:** Use roll cage washing machine to remove the dirt, sand and other debris.

3. **Peeling:** Use the mechanical friction peel mode, feed 30~40kg each time, the peeling time is determined by the degree of freshness of material, usually 3~8min. The peeled potatoes need to have net skin and smooth surface. Peeling time should not be too long or the potatoes will be excessive peeled. It will increase the loss rate of material.

4. **Trimming:** Remove the parts that unfit for human consumption which have buds, mildew and so on, and shape the irregular ones.

5. **Potato Slicing:** Feed the material into the potato slicing machine, feeding at a constant speed, the thickness should be 1~2mm.

6. **Blanching:** The potato slices should be immersed into water to blanch, in order to prevent browning in the air, and wash away the free starch of the surface to avoid the starch dissolving into the oil and shorten the life of frying oil.

7. **Color Protecting:** The temperature of the color protection solution should be 80~100°C and should destroy enzyme and improve the organizational structure. Usually the blanching time should be 1~2min. Besides that, it needs to add little additives.

8. **Potato Chips Dehydrating:** Spread the material stacked together on the sub-feeder, and remove surface water, to avoid increasing the frying time and increase the oil content of the final product.

9. **Potato Chips Frying:** The potato slices should be put into the oil at a constant speed. The oil temperature should be at 180~200°C. The chips should pass the frying pan in 2min. Palm oil is usually used in this process. It has good stability, long service life, good shortening properties, especially suitable for frying oil.

10. **Potato Chips De-oiling:** After frying, use the de-oiling machine to remove the oil of the surface, and it can extent the shelf life of the product.

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11. **Potato Chips Flavoring:** After flavored by seasoning machine, different flavor of potato chips are made. According to different tastes, there are potato chips of chicken flavor, beef flavor, spicy flavor and barbecue flavor etc.

12. **Potato Chips Cooling:** Cool the flavored potato chips to room temperature before packing.

13. **Weighing and Packaging:** The product needs quantitative packaging, net content error $\leq 10\%$. To extend the shelf life, it need the use of aluminum-plastic composite bag vacuum nitrogen packaging.

**III. Materials and Method**

1. **Materials:** potatoes (origin of Shanxi), palm oil, antioxidants, sodium metabisulfite, seasoning.

2. **Main equipment:** potato chips washing and peeling machine, potato chips slicing machine, potato chips blanching machine, potato chips frying machine, potato chips flavoring machine, fat extraction apparatus, and blast dry oven.

3. **How to choose the best raw materials:** If the reducing sugar content is high, the potato chips are easy to brown. The material of the potato chips need to be potatoes of relative density, which can increase the production and reduce the oil content. The experiment shows that, as the relative density of materials increases 0.1005, the production of potato chips will increase 1%. The relative density of the raw materials varies widely with different varieties, oil, planting method, harvest time and the weather and many other factors. Therefore, each batch of raw material are required to pass tests before production. During the harvest of raw material, the sugar content is relatively low. But after a period of storage at low temperature, the starch turns into sugar in the cells. So sugar increases and starches reduces.

**IV. Main Equipment and Technical Parameters of Automatic Potato Chips Plant**

**Main Equipment**

1. **Potato peeling machine:** Equipped with soft brush, potato washing and peeling machine can remove the thin peel completely and efficiently. The high peeling rate is up to 98% and ensures a good start and normal working speed in the whole potato chips line. Washing and peeling functions in a single machine to avoid repetitive labor and save time. This machine is easy to operate and clean.

2. **Potato slicing machine:** This machine can slice potatoes continuously, and make wave chips and plain chips by changing the cutter.
3. **Potato chips frying machine**: Use continuous deep stainless steel frying machine. The device is characterized by high yield, stable operation, and can make the material completely submerged in oil to fry in a row. The oil is heated outside the pan which is equipped with temperature control device to keep the oil temperature constant. The fryer is equipped with oil filter device to ensure remove the oil residue timely and prolong the service life of oil. It also has a hydraulic device, which can make the whole transport framework raised or lowered in the fryer and is easy to clean and maintain. The fryer must have a good exhaust system, in order to eliminate evaporation of fat ingredient in time and prevent the reflux of bad odor and oil rancidity.

**Technical Parameters of Potato Chips Production Line**

Through the studies above, the best technical parameters are as follows:

(1). The dry matter content of raw material is more than 20%;
(2). The thickness of potato chips is 1~2mm;
(3). The blanching temperature is 80~90°C and the time is about 1min;
(4). The frying temperature is 180~190°C and the frying time is 1~2min.

**V. Analysis**

**1. Material**

In order to produce high quality potato chips, increase product yield, reduce cost, it is important to choose the fresh potatoes that meet the technical requirements. Generally, potatoes need to be raw tubers neat, uniform size, shallow and small eyes, high content of starch and dry matter, and low level of reducing sugars. The reducing sugars content should be less than 1%. Because of reducing sugars and amino acids together producing black pigment protein, VC oxidizing discoloration, tannic substances browning, the sliced potatoes should be immersed in water to rinse and cut off oxygen, to avoid exposure to air and oxidation discoloration which will affect the color of the final product. Besides that, rinsing can remove the free starch of the surface. Color protection is to blanch potato chips in color protection solution of 80~100°C for 1~2min, to inactive enzyme and soften its organization structure, making it easy to dehydration. It can also exclude air within the potato tissue to prevent blistering on the surface. Generally, if add sodium bisulfite or metabisulfite additives to color protection solution, the color of the potato chips will be improved.

**2. Blanching and Anti-browning**

There are lots of factors causing browning, such as reducing sugars and amino acids together producing black pigment protein, VC oxidizing discoloration, tannic substances browning, the sliced potatoes should be immersed in water to rinse and cut off oxygen, to avoid exposure to air and oxidation discoloration which will affect the color of the final product. Besides that, rinsing can remove the free starch of the surface. Color protection is to blanch potato chips in color protection solution of 80~100°C for 1~2min, to inactive enzyme and soften its organization structure, making it easy to dehydration. It can also exclude air within the potato tissue to prevent blistering on the surface. Generally, if add sodium bisulfite or metabisulfite additives to color protection solution, the color of the potato chips will be improved.
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3. Frying
The frying process is the most important in producing potato chips. It plays a decisive role in color, oil content, and water content. While, the frying temperature and time have a direct relationship with the dry matter content, the thickness of chips and the degree of blanching. Through lots of experiments, we find that frying at a low temperature makes the frying time longer, water loss slow and increase the oil content. It is better to fry at high temperature and short time, but the temperature should be less than 200°C. Because if the frying temperature is too high, the fat will decompose and produce fatty acids. Fatty acids dissolve metal ions which are a catalyst for decomposition of oil and cause oil rancid and shorten the period of use of oil. High temperature causes potato chips excessive sugar caramelizing reaction which affects seriously the color and luster of the product. So we make the frying temperature at 180–190°C and the frying time in 2min and use stainless steel fryer. To prolong the life of frying oil can add antioxidants BHA and BHT and the total amount of antioxidants shall not exceed 0.12/kg fat. The oil content is related to many factors of the product. The higher the dry matter content of the product, the lower the oil content. Because the higher the dry matter content of the raw material, the more dense the organization, the lower the water content, and the shorter the drying time. Second the oil content is inversely proportional to the slice thickness. If the slice is too thin, it is easy to fry excessively and the oil content increase. Generally, the thickness is no less than 1mm.

VI. Conclusion
In short, the color and the oil content has a close relationship with the raw material, the thickness of slices, blanching and the frying process. With the most suitable technical parameters, potatoes can be made into bright color and crispy potato chips.