Fig. 3. a) Orange fleshed vacuum fried sweet potato chips rich in carotenoids b) Purple fleshed vacuum fried sweet potato chips rich in anthocyanin

CONCLUSION

Vacuum frying has proven to be a viable technology for producing healthy and nutritious fried foods with lower fat content and higher nutritional qualities such as β-carotene (provitamin-A) and anthocyanins content which aids in the prevention of many diseases. Low-fat, nutrient-dense vacuum-fried chips made from orange and purple fleshed sweet potato tubers were developed. The benefit-cost ratio for producing orange fleshed vacuum fried sweet potato chips is 2.13, while the benefit-cost ratio for producing purple fleshed vacuum fried sweet potato chips is 2.29. The findings of this study demonstrated the potential of vacuum frying as a method for producing healthy chips with lower fat content and higher nutritional characteristics.

TECHNICAL FOLDER :
VACUUM FRIED CHIPS FROM BIOFORTIFIED SWEET POTATOES

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VACUUM FRIED CHIPS FROM BIOFORTIFIED SWEET POTATOES

Vacuum frying is a promising food processing technology that preserves nutrients, colour, texture and flavor in ready-to-eat snacks. It involves simultaneous mass and heat transfer at very low temperatures and frying periods to give higher-quality products. During the frying process, many kinds of physical, chemical, and structural changes occur due to moisture evaporation, oil obstruction, gelatinization of starch, denaturation of protein structure, and solubilization of pectin cells. The vacuum frying process is usually performed at below atmospheric pressure. It also results in less oil degradation and less oxidation of volatile substances such as colour, flavour and vitamins. Oil absorption by the products is also reduced when compared to other frying methods. Another advantage of vacuum frying is that it reduces the development of acrylamide formation during the frying of starch-rich products such as sweet potato chips. However, to achieve a better texture in vacuum frying, the product should be pre-treated before frying.

Sweet potato is a popular tropical tuber grown for food purposes all over the world. Biofortified sweet potato (orange and purple flesh) cultivars are recognized as healthy foods due to their abundance of health-promoting compounds, essential minerals and dietary fiber. In this context, ICAR-CTCRI has developed two biofortified cultivars; Bhu Sona (orange flesh) and Bhu Krishna (purple flesh). The vacuum frying technique can be used to produce sweet potato chips with good retention of colour and health-promoting compounds from biofortified sweet potatoes, providing a diverse human health-focused diet, particularly to address diet-linked non-communicable chronic disease issues. Table 1 shows the nutritive values of fresh orange and purple fresh sweet potato tubers.

Table. 1. Nutritive values of orange and purple-fleshed sweet potato tubers

Nutrients	Orange flesh variety: Bhu Sona	Purple flesh variety: Bhu Krishna
Starch (%)	20.03	24.15
Sugars (%)	2.20	1.20
Fibre (%)	2.29	2.89
Protein (%)	0.40	1.42
Bioactive compound (mg/100 g)	14.04 (β-carotene)	75.00 (anthocyanin)

VACUUM FRYING SYSTEM:

A vacuum frying system consists of three components, viz., a) a vacuum frying chamber b) a refrigerated condenser and c) a vacuum pump (Fig. 1). The vacuum frying chamber is an airtight vessel provided with an oil heater and a frying basket. The frying basket is raised and lowered into the heated oil by a lift rod. The lift rod is usually connected to a spinner motor that is used for centrifuging the product after frying to get rid of surface oil. The refrigerated condenser is provided to trap the evolved steam during frying by condensing it on a cold surface. The use of a refrigerated condenser is recommended for better efficiency compared with water-cooled condensers. The vacuum pump provides the required low pressures for the process.

VACUUM FRYING PROCESS:

The vacuum frying process required the heating of oil to the required temperature. Then the sample to be processed has to be placed in the basket inside the frying chamber but suspended above the hot oil. The pressure inside the vacuum frying chamber has to be reduced to the required pressure. The sample then lowered into the hot oil for the required duration and then the basket to be raised above the oil and then centrifuged within the chamber for the required speed and time. The fried product can also be taken out of the chamber and centrifuged using a separate machine or stood in the frying chamber to drain the surface oil. The product is then placed on absorbent paper, cooled and packed in an aluminum laminate bag with or without nitrogen flushing.

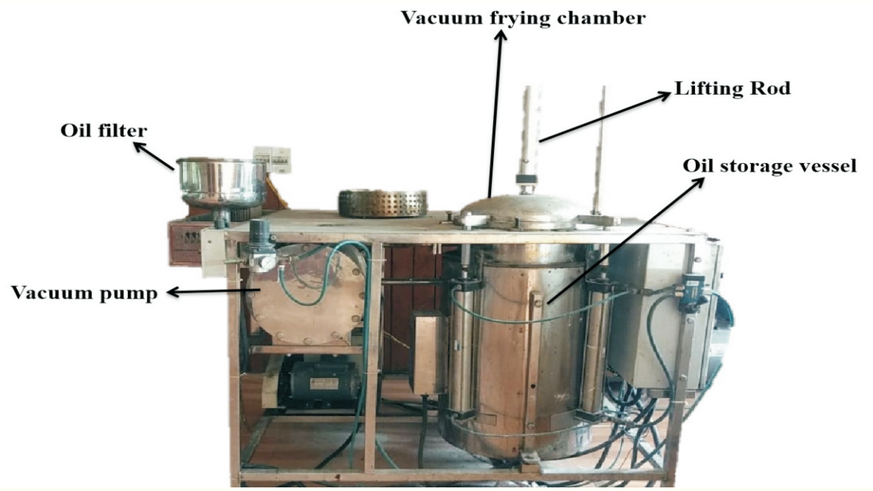

Fig.1: Vacuum frying system

Sweet potato tubers
↓
Washing & peeling
↓
Slicing @ 1.5 - 2.0 mm thickness
↓
Pretreatments
↓
Oil heating
↓
Depressurization
↓
Vacuum frying
↓
Deoiling & cooling
↓
Vacuum fried chips
↓
Packaging in Aluminium laminate bag

Fig. 2: Flow chart of vacuum fried sweet potato chips

ORANGE FLESHED SWEET POTATO CHIPS

The optimal conditions for vacuum frying orange fleshed sweet potato chips were found to be at 110°C with a vacuum pressure of 16.12 kPa for 7 min to produce healthy chips. When compared to deep fat fried chips, vacuum fried orange fleshed sweet potato chips had good retention of β-carotene content (6.80 mg/100g) and a 50.36% lower oil content (Table 3). Similarly, the moisture and oil content of optimized samples were 9.53% and 12.44%, respectively, which were lower than the 15.43% and 22.76% measured for deep fat fried chips (Fig. 3).

PURPLE FLESHED SWEET POTATO CHIPS

The optimal vacuum frying conditions were found to be 105°C with a vacuum pressure of 14.79 kPa for 7.08 min to produce healthy purple sweet potato vacuum fried chips. When compared to deep fat fried chips, purple sweet potato vacuum fried chips retained 86% more anthocyanin and had 35.6% less oil (Table 3; Fig. 3). Similarly, the moisture content, oil content, total colour difference (ΔE) and crispiness values for optimized vacuum fried samples were 7.30%, 12.30%, 10.46, and 0.71 N, respectively, which were lower than the values for deep fat fried chips samples of 13.78%, 19.10%, 27.10, and 3.43 N, respectively.

Table 3. Nutritional values of optimized vacuum fried and deep fried sweet potato chips

Nutrients	Orange flesh variety: Bhu Sona		Purple flesh variety: Bhu Krishna	
	Optimal value	Control (Deep fat fried)	Optimal value	Control (Deep fat fried)
Moisture (%)	**9.53**	**15.43**	**7.30**	**13.78**
Fat (%)	**12.44**	**22.76**	**12.30**	**19.10**
Total colour difference	**18.85**	**25.04**	**10.46**	**27.10**
Hardness (N)	**1.58**	**4.37**	**0.71**	**3.43**
Bioactive compound (mg/100 g)	**6.80** (β-carotene)	**4.28** (β-carotene)	**57.44** (anthocyanin)	**30.88** (anthocyanin)