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Processing and Value Addition of Onion in Sindh Province of Pakistan

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Abstract

Onion is largely cultivated in Sindh Province of Pakistan. Most of the fresh onion is wasted due to a lack of market and processing facilities. This study aims to develop new by-products from onion to increase the shelf life and nutritional value and reduce post-harvest losses. The fresh samples of onion were subjected to preparation of different products by following different processing methods, including sample selection, washing, cutting, removal of inedible parts, cutting, drying, curing, and packaging. The selected samples of onion powder, onion paste, onion pickle, and fried onions were analyzed for physico-chemical and sensory analysis. The results obtained for various products have shown significant variation in product quality. The low moisture content results in an extension of onion powder product shelf life and an increase in onion powder yield %. The findings demonstrate that processing method selection is a critical determinant of onion product quality, with dehydration and powdering offering the greatest potential for shelf-life extension and market diversification.

Keywords: Onion powder, onion shelf life, powder yield, quality.

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Introduction

In Pakistan, every year onions are grown and lost after harvest due to inadequate facilities of supply chain. Approximately 30–40% of onions are wasted annually [Ali, M., & Bukhari, S., 2020](#). According to the traditional harvesting practices applied in Pakistan, during processing, onion goes for absorbing environmental moisture, and results enzymatically spoilage, bad odor development, and excess water; appearance reduces onion quality [Sablani et al., 2008](#). The characteristic perishability of onions, compounded by instabilities in market prices, imposes considerable economic stress on producers and supply chain stakeholders [Rehman, F., & Shaikh, N., 2020](#). This challenge emphasizes the necessity for scientifically driven, innovative interventions aimed at minimizing post-harvest losses and optimizing value retention within the onion supply chain [Tamang et al., 2016](#)). The development of value-added products presents a viable approach, not only mitigating post-harvest deterioration but also enhancing income diversification for farmers, agro-processors, and exporters through the extension of shelf life and marketability. Value addition in agricultural produce refers to the process of converting raw commodities into processed forms that exhibit improved functionality, extended shelf life, and greater market attractiveness [Meilgaard et al., 2006](#). In the case of onions, value-added products may include dehydrated forms such as onion powder and flakes, as well as pickles, essential oils, and various onion-based snack items Ahmad. El al. (2024). These products not only enhance the usability and storage potential of onions but also open up new avenues for commercialization and income generation. Value-added onion products such as

powders, flakes, pastes, pickles, and essential oils have witnessed growing demand in both domestic and international markets, primarily due to their convenience, versatility, and extended shelf life [Kumar et al., 2017](#). These products cater to the evolving preferences of modern consumers, influenced by rapid urbanization, shifting dietary patterns, and an increasing demand for ready-to-use food ingredients [Sharma et al., 2016](#).

The market value chain for onion-based value-added products encompasses multiple interconnected stages, beginning with primary production and extending through post-harvest handling, processing, packaging, distribution, and retail Market Research [Future, 2023](#). Each stage adds incremental economic value and requires coordinated efforts among stakeholders, including farmers, processors, logistics providers, and retailers [Rehman & Shaikh, 2020](#). Efficient value chain integration not only enhances product quality and market access but also contributes to rural development by creating employment opportunities and improving income security for smallholder farmers and agro-processors ([FAO, 2023](#)).

Moreover, aligning the onion value chain with international food safety and quality standards can further enhance export potential, tapping into lucrative global markets. Strategic investment in infrastructure, capacity building, and technology adoption is essential to fully realize the economic benefits of value-added onion products within an increasingly competitive agri-food sector [Singh et al., 2023](#).

The potential for value addition in onions is particularly relevant to Sindh, where traditional agricultural practices often limit the scope for diversification and innovation. The province's rich onion-growing regions, such as Hyderabad,

Mirpurkhas, and Sanghar, possess untapped potential for establishing small-to medium-scale processing units [MRF, 2023](#)). However, the development of value-added products requires a comprehensive understanding of technical processes, market dynamics, and economic feasibility [Kumar. et al. \(2021\)](#). This study addresses these gaps by systematically evaluating six onion-based products using standardized processing methods and rigorous physico-chemical, functional, and sensory analyses [Khan & Saeed, 2021](#)).

Among the most common value-added products, onion powder holds significant promise due to its versatility and widespread use in culinary applications, seasoning blends, and instant food preparations [Khan & Saeed, 2021](#). Onion powder offers a convenient alternative to fresh onions, particularly in regions with limited access to fresh produce. Its production involves dehydration and grinding processes that preserve the nutritional and flavor profiles of fresh onions while extending their shelf life [\(Ahmad et al., 2024](#). Similarly, onion flakes serve as a rehydration-friendly ingredient used in soups, sauces, and ready-to-eat meals. The production of onion flakes is an energy-efficient process that ensures minimal nutrient loss, making it a cost-effective option for value addition [Sharma et al., 2016](#)).

Another high-demand product is onion pickle, a traditional condiment in South Asian cuisine that offers a blend of tangy and spicy flavors. Pickling onions enhances their palatability and preserves them for extended periods, providing a viable solution to surplus crop utilization. The process involves a combination of brining, vinegar infusion, and spice addition, tailored to consumer preferences. Additionally, onion essential oil has emerged as a niche product in the food,

pharmaceutical, and cosmetic industries. Extracted through steam distillation, onion oil contains bioactive compounds with antimicrobial, anti-inflammatory, and antioxidant properties, making it a valuable ingredient in natural remedies and skincare formulations [Patil et al., 2019](#).

The global demand for onion-based value-added products has witnessed substantial growth in recent years, driven by advancements in food processing technology and increasing consumer awareness of convenience foods. According to market research, the global onion powder market is projected to grow at a compound annual growth rate (CAGR) of 5.8% between 2023 and 2030 [Singh et al., 2023](#). This trend presents a lucrative opportunity for Pakistan to enhance its share in the processed onion market, particularly in regions like the Middle East, Europe, and Southeast Asia. However, realizing this potential requires addressing critical challenges, including supply chain inefficiencies, lack of processing infrastructure, and quality assurance standards [Patil et al., 2019](#).

The research community has highlighted the role of value addition in promoting agricultural sustainability and rural development. Studies have shown that value-added products contribute to reducing post-harvest losses, increasing farmers' income, and creating employment opportunities in rural areas [\(Kumar et al., 2021\)](#). In the context of Sindh, these benefits are particularly relevant given the province's dependence on agriculture and the socio-economic vulnerabilities of its farming communities [Lawless & Heymann, 2010](#). Moreover, value addition aligns with the Government of Pakistan's agricultural policy objectives, which emphasize the need for diversification, export promotion, and poverty alleviation through agro-based industries [Tamang et](#)

al., 2016). This study aims to contribute to the growing body of knowledge on agricultural value addition by focusing on onions, a crop of strategic importance to Sindh's economy Sablani et al., 2008.

2. Materials & methods used:

Sample collection

Materials

Fresh onions (*Allium cepa*) were purchased from a local market in Tando Jam, Sindh, Pakistan. The onions were selected based on their uniform size and were free from visible defects. All chemicals used in the preparation of the products, including sodium chloride for pickling, were of analytical grade and purchased from standard chemical suppliers.

Preparation of Onion Products

The following onion products were prepared according to the methods presented in Table 1 and outlined below:

1. **Fresh Onion:** Fresh onions were peeled, washed, and sliced into uniform rings (approximately 2 mm thick). These slices were stored immediately at ambient temperature for sensory evaluation and other analyses.
2. **Dehydrated Onion:** The onion slices were washed, peeled, and sliced into 2 mm-thick pieces. These slices were subjected to a dehydration process using a hot air oven (at 60°C for 24 hours) until the moisture content was reduced to approximately 7-10%. The dried slices were ground into a coarse powder.
3. **Fried Onion:** Onion slices were washed, peeled, and sliced into 2 mm thick rings. These rings were deep-fried in vegetable oil at 180°C for 2 minutes until they were golden brown. The fried onion was then drained of excess oil using paper towels and allowed to cool before packaging.
4. **Onion Pickle:** Onion slices were peeled

and sliced as in the fresh onion preparation. The slices were then immersed in a brine solution (1:1 ratio of vinegar and water, with 2% sodium chloride) for 3 days at room temperature. The pickle was then stored in glass jars under refrigerated conditions.

5. **Onion Powder:** Onion slices were dehydrated as described above and then ground into a fine powder using a mechanical grinder. The onion powder was stored in airtight containers to prevent moisture absorption.
6. **Onion Rings:** Onion slices were peeled and cut into 2 mm thick rings. The rings were dipped in a batter made from flour, water, and seasonings, then deep-fried at 180°C for 2-3 minutes until golden brown. The excess oil was drained, and the onion rings were allowed to cool before packaging.

Annexure (A)

3. Experimental analysis

a. Sample analysis

The samples of fresh and healthy onion (*Allium cepa* L.) were selected and purchased from the local fruits and vegetable market of Hyderabad, Sindh. In total, 20 kg of onion were purchased and brought to the laboratories of the Institute of Food Sciences and Technology for processing. The outer layers of the onion were removed manually with the help of a knife, and the bulbs were sliced into thin rounds (thickness 5 ± 0.2 mm) using a knife. The sliced onions were then dried using a hot air tray dehydrator at a temperature of 60 °C) for 24 h. The dried onion slices were ground into a fine powder using a mixer grinder.

The onion powder was sieved using a sieve with a mesh size 100 (150 µm particle size) after sieving the onion powder packaged in airtight glass jars and stored at room temperature for physico-chemical

and sensory analysis. Fresh onions were used as the control sample. This sample preparation process was repeated three times to obtain replicates, and the results were averaged to obtain the final values.

b. Physico-chemical analysis

c. Determination of Moisture (%)

The moisture content of each onion sample was determined using the hot-air-oven method by drying a 100 g sample in an oven maintained at a temperature of $105 \pm 5^\circ\text{C}$ according to the procedure described in AACC (2000) method No. 44-15 A. The loss of weight was recorded as a measure of moisture content and was calculated by the following formula:

Moisture (%) = $\frac{\text{Weight of fresh sample} - \text{weight of dry sample}}{\text{Weight of fresh sample}} \times 100$

Weight of fresh sample

d. Determination of Ash %

The ash % of each onion sample was estimated by putting the sample in a muffle furnace at a temperature of $525 \pm 5^\circ\text{C}$ till white-grey residues were obtained, as per the method described in AACC (2000) method No. 08-01.

According to the method, 5 g of each sample was weighed in a silica crucible. The crucible was heated in a muffle furnace for about 3-5 hours at 525°C . It was cooled in a desiccator containing a moisture absorbent (silica gel) for one hour and was weighed. To ensure completion of ashing, it was repeated until the weight became constant (ash became white or greyish white). The ash % of the onion sample was calculated by the following formula.

Ash % = $\frac{\text{Weight of onion sample after ashing}}{\text{Weight of fresh onion sample taken}} \times 100$

d. Total soluble solids (TSS) °Brix

TSS of each onion product sample was calculated using a digital refractometer, and the results were observed as °Brix. 2 g sample was mixed with 8 mL distilled water, and the mixture was homogenized

for 2 min; then a few drops of the sample were placed on the refractometer prism, and the obtained values were recorded.

pH of each sample was determined using a Digital pH meter. 2 g onion sample was blended with 10 mL distilled water (Dilution factor: 5) for 2 min. The sample was then filtered, and the pH of the filtrate was measured using the pH meter at 25°C .

e. Functional properties of onion samples

Functional properties: Bulk density, water holding capacity, oil absorption capacity, and powder yield were measured according to standard methods [Ziteng et al 2023](#).

f. Bulk Density

The bulk density of each onion sample was assessed by following the method of Mullarney and Beach. The weight (w) and volume (v) of the onion sample were measured using an analytical balance to record the sample weight and a graduated cylinder, respectively. The bulk density was determined using the following equation

$$\text{BD (g/mL)} = W / V$$

Water holding capacity (WHC)/OHC

The water holding capacity of the onion sample was determined by the method of [Ziteng et al. \(2023\)](#) with slight modification. 1 g of sample was added to a 15 mL centrifuge tube, to which 10 mL of distilled water was added. The mixture was vortexed for 1 min, left to stand for 30 min, and then centrifuged at 3000 g for 10 min at 25°C . The supernatant was removed, and the wet sediment of the sample was weighed. The WHC was calculated as the weight of the wet sediment (WS) divided by the weight of the original sample (WD), expressed as a percentage. The following equation was used to calculate WHC.

$$\text{WHC} = \text{WS} / \text{WD} \times 100\%$$

4. Statistical Analysis:

The data obtained in all the experiments were tabulated in MS Excel of

MS Office 2013, subjected to statistical analysis using the standard procedures for analysis of variance, ANOVA (one-way ANOVA), and mean comparison (Least significant difference, LSD). All parameters were analyzed using the Statistics 8.1 computer software (**Statatix, 2006**).

5. Results/discussion:

Table 2. Physico - Chemical and Functional Properties of Onion Products

Parameters	Fresh Onion	Dehydrated Onion	Fried Onion	Onion Pickle	Onion Powder	Onion Rings
Moisture Content (%)	88.2 ± 0.3 ^a	7.3 ± 0.2 ^d	55.8 ± 0.4 ^b	82.1 ± 0.5 ^c	5.1 ± 0.3 ^d	60.4 ± 0.3 ^b
Ash Content (%)	0.5 ± 0.1 ^b	3.2 ± 0.2 ^a	2.1 ± 0.1 ^a	2.8 ± 0.1 ^a	4.5 ± 0.2 ^a	2.4 ± 0.2 ^a
Total Soluble Solids (°Brix)	5.2 ± 0.1 ^b	4.3 ± 0.2 ^c	6.7 ± 0.3 ^a	5.5 ± 0.2 ^b	7.2 ± 0.1 ^a	6.8 ± 0.2 ^a
pH	5.7 ± 0.1 ^b	5.8 ± 0.1 ^b	5.9 ± 0.2 ^b	4.1 ± 0.2 ^a	5.4 ± 0.1 ^b	5.5 ± 0.1 ^b
Functional Properties						
Bulk Density (g/cm ³)	0.85 ± 0.03 ^b	0.40 ± 0.05 ^a	0.63 ± 0.02 ^b	0.78 ± 0.02 ^b	0.75 ± 0.03 ^b	0.62 ± 0.01 ^b
Water Holding Capacity (g/g)	4.1 ± 0.2 ^a	1.2 ± 0.1 ^d	2.8 ± 0.1 ^b	3.0 ± 0.2 ^b	1.1 ± 0.1 ^d	3.5 ± 0.1 ^a
Oil Absorption Capacity (g/g)	2.5 ± 0.1 ^a	0.8 ± 0.1 ^c	3.4 ± 0.3 ^a	2.9 ± 0.2 ^a	0.5 ± 0.2 ^c	3.1 ± 0.1 ^a
Powder	---	92.4 ± 1.2 ^a	---	---	85.3 ± 1.5 ^b	---

Yield (%)						
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Table 2 presents the results of moisture content of the onion products varied significantly, reflecting the effects of different processing methods. Fresh onion had the highest moisture content ($88.2 \pm 0.3\%$), consistent with its high water content in its natural form. Dehydrated onion had the lowest moisture content ($7.3 \pm 0.2\%$), as the dehydration process removes the majority of water, resulting in a dry product. Fried onion and onion rings showed intermediate moisture levels ($55.8 \pm 0.4\%$ and $60.4 \pm 0.3\%$, respectively), likely due to oil absorption during frying, which reduces water content but retains some moisture. Onion pickle, which is preserved in brine, exhibited a moisture content of $82.1 \pm 0.5\%$, indicating the high water content retained in the pickling solution.

Ash content, a measure of the mineral content, varied among the onion products. Onion powder demonstrated the highest ash content ($4.5 \pm 0.2\%$), suggesting that dehydration and grinding concentrate minerals. Similarly, dehydrated onion had a relatively high ash content ($3.2 \pm 0.2\%$), which is typical for dried products. In contrast, fried onion and onion pickle exhibited lower ash values ($2.1 \pm 0.1\%$ and $2.8 \pm 0.1\%$, respectively), indicating that frying and pickling processes dilute the mineral content. Fresh onion, with its high water content, had the lowest ash content ($0.5 \pm 0.1\%$) **Savitha et al., 2022**.

The °Brix value, representing the total soluble solids (including sugars and soluble compounds), was highest in onion powder ($7.2 \pm 0.1^\circ\text{Brix}$), reflecting the concentration of sugars during the dehydration process. Fried onion also exhibited a high °Brix value ($6.7 \pm 0.3^\circ\text{Brix}$), likely due to the Maillard reaction, which occurs during frying and contributes to the formation of sugars and flavor compounds.

Fresh onion and onion pickle showed moderate °Brix values ($5.2 \pm 0.1^\circ\text{Brix}$ and $5.5 \pm 0.2^\circ\text{Brix}$, respectively), consistent with the natural sugar content of raw onions and the slight dilution of solids during pickling Van Boekel, M. A. J. S., 2021. Dehydrated onion had the lowest °Brix value ($4.3 \pm 0.2^\circ\text{Brix}$), which is typical due to the loss of soluble solids during drying.

The pH of the onion products ranged from mildly acidic to neutral. Fresh onion and dehydrated onion had similar pH values (5.7 ± 0.1 and 5.8 ± 0.1 , respectively), indicating a neutral to slightly acidic pH typical of most fresh vegetables. Fried onion exhibited a slightly higher pH (5.9 ± 0.2), which can be attributed to the neutralizing effects of the frying process. Onion pickle, on the other hand, had a significantly lower pH (4.1 ± 0.2), reflecting the acidic nature of the brine used for preservation. Onion rings had a pH of 5.5 ± 0.1 , which is consistent with the mildly acidic nature of fried foods. Onion pickle achieved moderate acceptability, attributed to the presence of spices and fermentation-related flavor enhancement (Tamang et al., 2016).

Functional properties such as bulk density, water holding capacity, and oil absorption capacity provide insights into the textural and performance characteristics of the onion products. The onion powder sample exhibited the lowest ratings due to oxidation and volatile losses during processing and storage (Sablani et al., 2008). Bulk density was highest in fresh onion ($0.85 \pm 0.03 \text{ g/cm}^3$) and lowest in dehydrated onion ($0.40 \pm 0.05 \text{ g/cm}^3$), indicating the greater compactness of fresh onion and the more porous nature of dehydrated products Mullarney, M. P., & Beach, L. E., 2020. The bulk density of each onion sample was assessed by following the method of Mullarney and Beach. Water-holding capacity was highest in

fresh onion ($4.1 \pm 0.2 \text{ g/g}$) and onion rings ($3.5 \pm 0.1 \text{ g/g}$), suggesting that these products can absorb and retain more water. Dehydrated onion showed the lowest water-holding capacity ($1.2 \pm 0.1 \text{ g/g}$) due to its reduced water content. Oil absorption capacity was highest in fried onion ($3.4 \pm 0.3 \text{ g/g}$) and onion rings ($3.1 \pm 0.1 \text{ g/g}$), reflecting the typical oil uptake during frying. In contrast, onion powder had the lowest oil absorption capacity ($0.5 \pm 0.2 \text{ g/g}$), as it is a dry product.

The onion powder yield was determined by the percentage of the original onion weight that was converted into onion powder. Dehydrated onion exhibited the highest powder yield ($92.4 \pm 1.2\%$), reflecting minimal loss during the dehydration and grinding process. Onion powder showed a slightly lower yield ($85.3 \pm 1.5\%$), which is expected due to minor losses during the grinding and sieving process.

Table 3. Mean $\pm$ SD Scores of Onion Products on 9-Point Hedonic Scale

Onion Product	Appearance	Color	Flavor	Texture	Taste	Overall Acceptability
Dehydrated Onion	6.8 ± 0.5^d	6.5 ± 0.6^{cd}	6.2 ± 0.7^c	6.4 ± 0.5^{cd}	6.3 ± 0.6^{cd}	6.5 ± 0.4^{cd}
Fried Onion	8.0 ± 0.4^a	8.2 ± 0.3^a	8.1 ± 0.4^a	8.0 ± 0.5^a	8.3 ± 0.3^a	8.1 ± 0.2^a
Onion Pickle	7.2 ± 0.6^b	7.0 ± 0.5^b	7.3 ± 0.4^b	6.9 ± 0.5^{bc}	7.5 ± 0.3^b	7.2 ± 0.4^b
Onion Powder	6.0 ± 0.7^c	6.3 ± 0.5^{cd}	6.1 ± 0.6^c	6.0 ± 0.4^d	6.2 ± 0.5^{cd}	6.1 ± 0.6^d
Onion Rings	8.5 ± 0.3^a	8.4 ± 0.2^a	8.6 ± 0.3^a	8.7 ± 0.2^a	8.8 ± 0.1^a	8.6 ± 0.2^a

Fresh Onion	7.5 ± 0.5 ^b	7.4 ± 0.4 _b	7.6 ± 0.3 ^b	7.2 ± 0.6 ^b	7.4 ± 0.5 _b	7.4 ± 0.4 ^b
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Different superscript letters (a–e) within a column indicate significant differences at $p < 0.05$ (one-way ANOVA followed by post hoc t-test).

The sensory evaluation of six onion-based products results are presented in table-3 for dehydrated onion, fried onion, onion pickle, onion powder, onion rings, and fresh onion was conducted using a 9-point hedonic scale to assess consumer preferences for appearance, color, flavor, texture, taste, and overall acceptability. The results, summarized in Table 2, revealed statistically significant differences among the samples ($p < 0.05$), confirming the influence of processing methods on sensory characteristics.

Onion rings exhibited the highest overall acceptability (8.6 ± 0.2), followed closely by fried onion (8.1 ± 0.2). These results are consistent with previous studies demonstrating that deep frying enhances flavor and texture through Maillard browning and the development of volatile flavor compounds (Brennand & Butterfield, 1992; Lawless & Heymann, 2010). The appealing color, crispness, and intensified taste of these products significantly contributed to their superior scores.

Onion pickle achieved moderate acceptability (7.2 ± 0.4), with favorable responses for flavor (7.5 ± 0.3) and taste, attributed to the presence of spices and fermentation-related flavor enhancement (Tamang et al., 2016). However, variability in appearance and texture slightly reduced its overall appeal.

Fresh onion was also well-accepted (7.4 ± 0.4), primarily for its crisp texture and pungent, characteristic flavor. This aligns with findings by Meilgaard et al. (2006), who noted that consumers often prefer raw

onion in salads and garnishes due to its freshness and bite.

In contrast, dehydrated onion received a lower overall acceptability (6.5 ± 0.4), likely due to a reduction in volatile flavor compounds and changes in texture resulting from the drying process (Ratti, 2001). The onion powder sample exhibited the lowest ratings (6.1 ± 0.6) across most sensory attributes, suggesting limited appeal as a stand-alone product. Its lower scores may be explained by its dull appearance and reduced aromatic intensity, which are common in powdered seasonings due to oxidation and volatile losses during processing and storage (Sablani et al., 2008).

Overall acceptability, these results revealed that sensory perception of onion products is significantly influenced by the method of processing. Frying and pickling techniques tend to preserve or enhance sensory attributes, while dehydration and powdering often compromise flavor and texture. These findings are essential for guiding the development of value-added onion products tailored to consumer preferences.

6. Conclusion:

The findings from this study concluded that the significant impact of processing methods on the physico-chemical and functional properties of onion products. Dehydrated onion and onion powder resulted in the highest levels of powder yield %, low moisture % levels, making them ideal for extended shelf life and use in various culinary applications. Fried onion and onion rings exhibited moderate moisture and oil absorption properties, which are characteristic of fried foods and contribute to their texture and flavor. Onion pickle, with its high acidity and moisture content, provides a distinct flavor and preservation method. The sensory scores of fried onion and onion rings

highlight consumer preference for onion-based processed products, though the higher oil content of these items warrants further optimization for health-conscious markets. These results contribute to a deeper understanding of how processing affects the quality and functionality of onion-based products, providing valuable results for both manufacturers and consumers to preserve onion into various by-products; it will also help onion market growth and industrialization.

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Annexure (A)**Table 1.** Onion Sample Processing into various by-products

Product	Processing Method	Time & Temperature	Key Parameters	References
Fresh Onion	1. Peel, wash, and slice onions into rings (2 mm thickness).	Ambient temperature (25°C)	No significant processing beyond slicing and storage.	Hussain et al., 2013
Dehydrated Onion	1. Peel, wash, and slice onions into rings (2 mm thickness). 2. Dry in a hot air oven.	60°C for 24 hours	Moisture content reduced to 7-10%.	Kumar et al., 2015
Fried Onion	1. Peel, wash, and slice onions into rings (2 mm thickness). 2. Deep-fry in vegetable oil.	180°C for 2 minutes	Fried to golden-brown, drain excess oil, and cool.	Sharma et al., 2016
Onion Pickle	1. Peel, wash, and slice onions into rings. 2. Immerse in brine solution (1:1 vinegar and water with 2% NaCl).	3 days at room temperature (25°C)	Pickled in brine for 3 days.	Kumar et al., 2017
Onion Powder	1. Peel, wash, and slice onions into rings. 2. Dehydrate in a hot-air oven. 3. Grind into fine powder.	60°C for 24 hours, then grind	Ground into a fine powder, packed in moisture-proof containers.	Singh et al., 2014
Onion Rings	1. Peel, wash, and slice onions into rings. 2. Dip in batter and deep-fry in oil.	180°C for 2-3 minutes	Golden-brown, crispy texture, excess oil drained.	Patil et al., 2019