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"EFFECT OF OZONE GAS ON FOOD PROCESSING"

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ABSTRACT

An Ozonized food processor is designed according to dielectric barrier discharge (DBD) technique with Oxygen as a feed gas for Ozone generating which is further used in purification of vegetables and fruits.The potential utility of ozone in food processing lies in the fact that ozone is a 52% stronger oxidant than chlorine. The widespread use of chlorine by the food industry is under scrutiny and the acceptance of chlorine as the primary sanitizing agent for food process operations is being reconsidered by many processors and regulators. By law, ozone is classified as a food additive thus its use in or on food is regulated. This classification disallows for ozone's use as a direct contact food sanitizing agent.

The focus of this work is to determine the efficacy of ozone in the sanitation of whole, fresh fruits and vegetables. Research studies, using ozone in pure water as a direct contact sanitizing agent have been conducted on several agricultural commodities and the results are promising. Ozone does not leave a chemical residual and for some industrial sanitizing operations this may be seen as a disadvantage. But, when it comes to our food supply, no residual, and fewer residual by-products is a distinct advantage.

KEYWORDS: *Butterfly Valve, FEM, CAD design, Stress, Deformation, CATIA, ANSYS*

I. INTRODUCTION

Ozone, a triatomic form of oxygen is an extremely potent oxidant having a broad antimicrobial spectrum.

It is an allotrope of oxygen that is much less stable than the diatomic allotrope breaking down in the lower atmosphere to normal dioxygen. Ozone is formed from dioxygen by the action of ultraviolet light and also atmospheric electrical discharges, and is present in low concentrations throughout the Earth's atmosphere (stratosphere). In total, ozone makes up only 0.6 ppm of the atmosphere.

Ozone's odour is sharp, reminiscent of chlorine, and detectable by many people at concentrations of as little as 10 ppb in air. Ozone's O3 structure was determined in 1865. The molecule was later proven to have a bent structure and to be diamagnetic. In standard conditions, ozone is a pale blue gas that condenses at progressively cryogenic temperatures to a dark blue liquid and finally a violet-black solid. Ozone's instability with regard to more common dioxygen is such that both concentrated gas and liquid ozone may decompose explosively at elevated temperatures or fast warming to the boiling point. It is therefore used commercially only in low concentrations.

Ozone is a powerful oxidant and has many industrial and consumer applications related to oxidation. This same high

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oxidising potential, however, causes ozone to damage mucous and respiratory tissues in animals, and also tissues in plants, above concentrations of about 100 ppb. This makes ozone a potent respiratory hazard and pollutant near ground level. However, the ozone layer (a portion of the stratosphere with a higher concentration of ozone, from two to eight ppm) is beneficial, preventing damaging ultraviolet light from reaching the Earth's surface, to the benefit of both plants and animals.

Ozone is created in the atmosphere when the sun's rays split oxygen molecules into single atoms. These atoms combine with nearby oxygen to form a three-oxygen molecule, called ozone. Even as it's being made, ozone is also destroyed by sunlight and reactions involving natural compounds that contain chlorine, nitrogen, and hydrogen. Most of the earth's ozone is contained in the stratosphere, a layer of the atmosphere 10–40 km above the surface of the earth. The amount of ozone in the stratosphere is fairly constant when viewed globally. However, it changes throughout the year and from one place to another. Most of the world's ozone is created over the Tropics, and is then pushed by stratospheric winds over the rest of the planet.
Ozone is formed photochemically in the stratosphere, in high-voltage electrical arcs, in photochemical smog and by ultraviolet (UV) sterilisation lampsandgammaradiationplants(Mustafa1990).Thecharacteristicfresh, clean smell of air following a thunderstorm represents freshly generated ozone in our atmosphere. The passage of new regulations (please see Chapter 2) and broad spectrum application may make ozone a greener alternative to traditional approaches for various food applications. Generally Recognised as Safe (GRAS) status and US Food and Drug Administration (FDA) approval of ozone as an antimicrobial agentfor direct food contact (FDA 2001) have allowed ozone to be used in food pro- cessing.Becauseofresidualcompoundsandreactionbyproducts,chemical sanitising agents have come under scrutiny. For example, chlorination byproducts such as trihalomethanes and chloramine compounds are potentiallycarcinogenic(Pascualetal.2007).Ozonereactionproductsfrom oxidation of organic compounds, such as aldehydes, ketones or carboxylic acids,havenotbeenreportedtohaveadversehealthconsequences(Pascual etal.2007).Ozoneisalsoconsideredasanalternativetochlorinetoprevent the formation of halogenated organic compounds. However, the efficacy of ozone on food and food products within the food industry depends on its physicochemical properties. This chapter discusses the physical, chemical and antimicrobial properties of ozone as they apply to the food industry.

II. METHODOLOGY

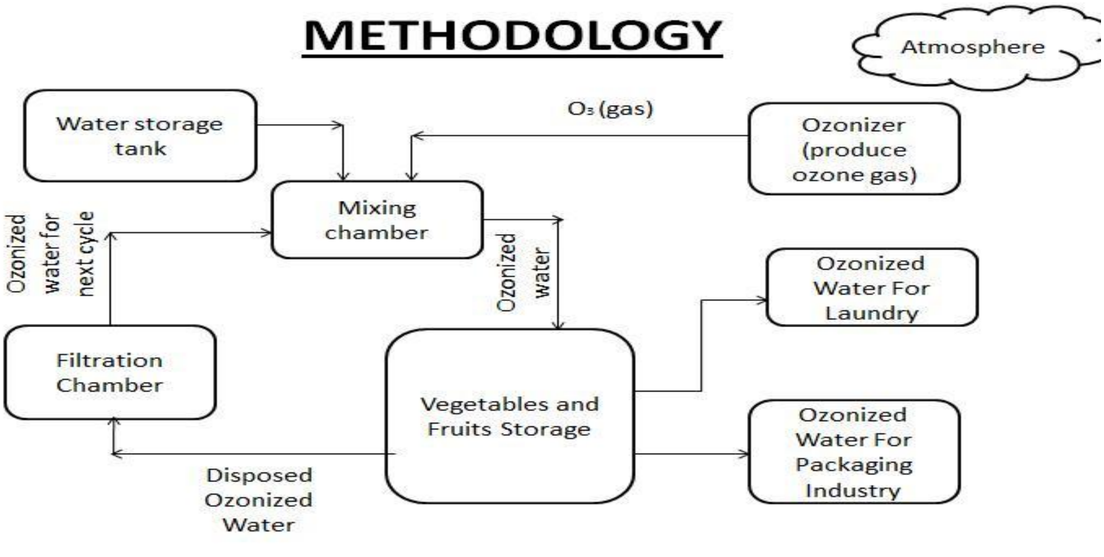

Figure 2: Block Diagram of the process

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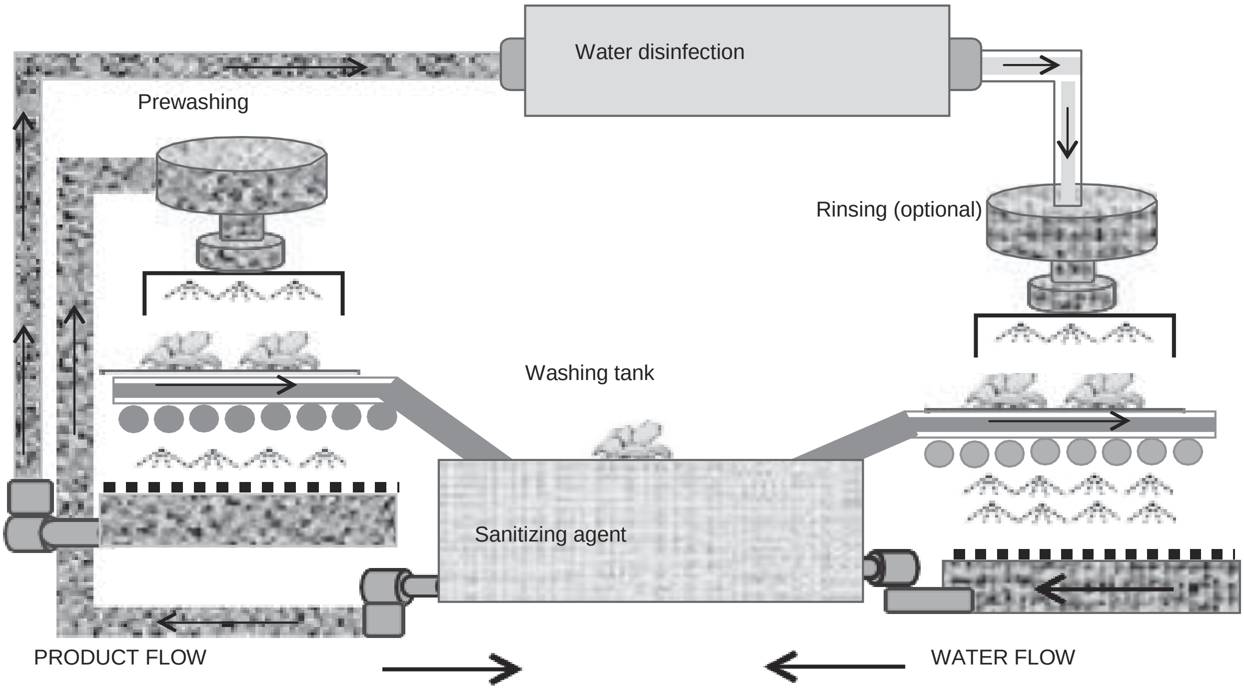
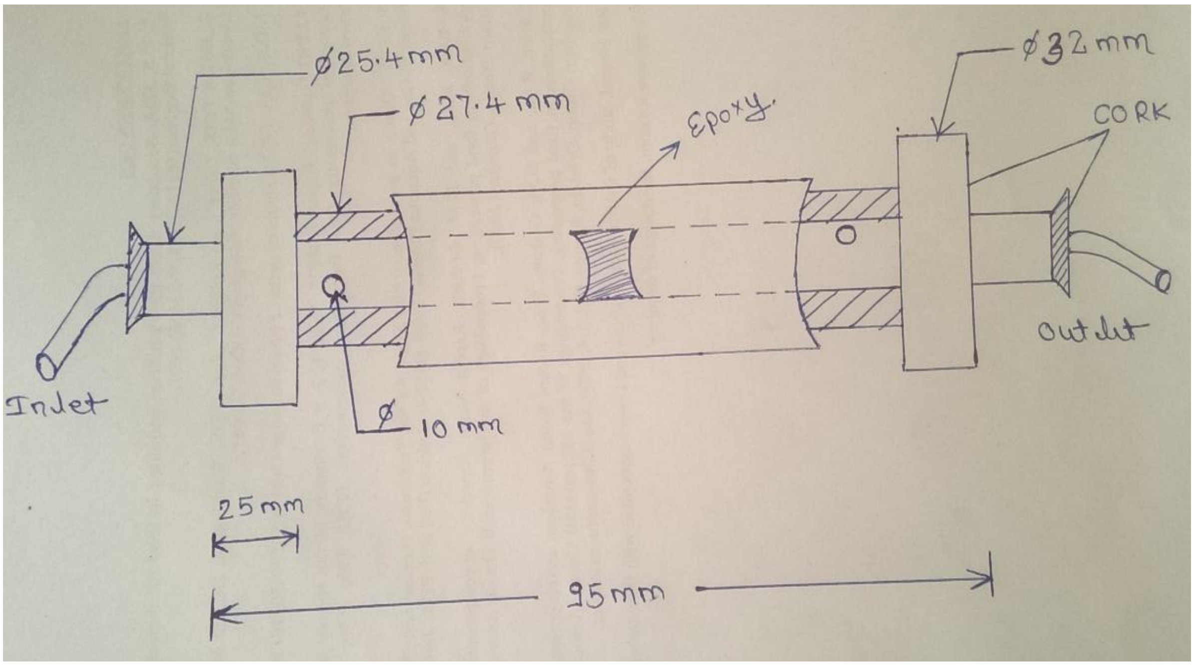


Figure 2: Schematic of the process



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III. EFFECTS OF OZONE

Table 1: Advantages and limitations of disinfection methods proposed for fresh-cut organic vegetables

Disinfectantagent	Advantages	Disadvantages/limitation
Chlorine (hypochlorite)	Low cost Easily available	Hazardous DBP at high levels Reacts with organic matter, in some cases leads to the production of toxic compounds Efficacy is affected by the presence of organic matter Corrosive Activity pH dependent Not allowed for organic products
Ozone	High antimicrobial activity Short contact time GRAS substance No residue problem No hazardous DBP formation No need to store hazardous Substances Lower running cost Requires onsite generation	Toxic when inhaled Requires monitoring in indoor Applications Corrosive above 4 ppm Higher initial investment cost
Chlorine dioxide	Higher antimicrobial efficacy at neutral pH than chlorine Effectiveness less pH dependent than that of chlorine Fewer potentially hazardous DBP formation than chlorine Less corrosive than chlorine and Ozone Requires onsite generation	Not efficient at permitted levels for fresh Produce Explosive Only allowed in whole produce Final water rinsing is required after Treatment More iodinated DBP formation than chlorine if iodide ion is present in water Formation of specific byproducts, chlorite and chlorate Requires monitoring in indoor Applications Not allowed for organic products
Organic acids	Easy to use No toxicity	Long contact time, not relevant to the Industry Interferes with the sensory quality

	Allowed for organic products	Relatively lower antimicrobial efficacy
Peroxyacetic acid	Efficacy is not affected by the organic load of water Efficacy unaffected by temperature Changes No harmful DBP formation Not corrosive at permitted levels (<80 ppm)	Low antimicrobial efficacy at permitted levels for vegetables Not allowed for organic products
Hydrogen peroxide	No residue problem Easy to use Low cost	Low antimicrobial efficacy Long contact time Phytotoxic, negative impact on overall Quality Requires the removal of residual H_2O_2 after processing Not allowed for organic products

Effect of ozone on fruit and vegetable preservation and quality.

Foodproduct	Target microbial population	Quality attributes
Aqueous ozone treatment		
Lettuce	*Shigella sonnei* (1.8LR)	
Iceberglettuce	APC (1.1 LR)	Shelf life (□), visual sensory quality (□)
Apple	*E.coli*O157:H7(3.7LR)	
	E. coli O157:H7 (2.6 LR)	
Coriander	TPC (□)	Aroma (□), flavour (□), overall quality (□)
		Colour (□)
Lettuce	*E.coli*O157:H7 (1.42LR)	
Babycarrot	*E.coli*O157:H7(1.8LR)	
Watermelon	APC (1–1.5LR)	Colour (□), overall quality (□)
Celery	Total bacteria (1.15LR) PPO (□)	Total sugar

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		(□), colour (□)
Lettuce	PPO (□)	Antioxidants (□), vitamin C (□), visual appearance (□)
Fresh-cutpotato strips	LAB(□), coliforms (□) and anaerobic bacteria(□)	Shelf life (□), non-enzymatic browning (□)
Blueberries	*E.coli*O157:H7(3.0LR)	Colour (□)
Gaseous ozone treatment		
Lettuce	*E.coli*O157:H7 (1.84LR)	Colour (□)
Babycarrot	*E.coli*O157:H7(2.64LR)	
Greenpepper	*E.coli*O157:H7(5LR)	

Application of ozone during storage of fruits and vegetables

Food product	Storage conditions	Target Microbial population	Salient findings
Carrot	Ozone concentration of 0 (control), 7.5, 15, 30 or 60 □l/L. Treatment chambers were flushed with a total flow rate of 0.5 L/min (air and ozone) for 8 hours daily for 28 days. The experiment was repeated twice at storage temperatures of 2, 8 and 16 °C.	*Botrytis cinerea* Pers. and *Sclerotinia sclerotiorum* de Bary	A 50% reduction of daily growth rates of both fungi at the highest ozone concentration indicated that ozone was fungistatic. Carrot respiration rate, electrolyte leakage and total colour differences increased with ozone concentration. Ozone-treated carrots were lighter (higher L* values) and less intense (lower chroma values) in colour than control carrots.
Carrot	Ozone concentration of 50 □ 10 nl/L ozone during storage for up to 6 months at 0.5 °C and □95% relative humidity.	*Sclerotinia sclerotiorum* and *Botrytis cinerea*	Reduced lesion size and aerial mycelium of both pathogens. Ozone-induced injury, appearing as blotches of brownish discoloured periderm. Ozone treatment had no effect on fresh weight loss, sprouting of carrot crowns or concentrations of glucose, fructose, sucrose or galactose.
Blackberry	Stored for 12 days at 2 °C in	Fungal decay (*Botrytis*	Ozone storage suppressed fungal

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	0.0, 0.1 and 0.3 ppm ozone.	*cinerea*)	development for 12 days. Ozone storage did not cause observable injury or defects. On day 12, anthocyanin content of juice was similar to initial levels for all treatments. Surface colour was better retained in 0.1 and 0.3 ppm-stored berries by 5 days and in 0.3 ppm berries by 12 days, by hue angle values. POD was greater in controls and 0.1 ppm samples, and was lowest in 0.3 ppm fruits by 12 days.
Strawberry (*Fragaria* × *ananassa* Duch. cv. Camarosa)	Strawberry fruits were stored at 2 °C in an atmosphere containing ozone (0.35 ppm). After 3 days at 2 °C, fruits were moved to 20 °C to mimic retail conditions.	Fungal decay (*B. cinerea*)	Ozone treatment was ineffective in preventing fungal decay in strawberries after 4 days at 20 °C. Significant differences in sugars and ascorbic acid (reduced by 3 times) content were found in ozone-treated strawberries.

IV. EFFICACY OF OZONE

Efficacy of ozone is affected by both extrinsic candintrinsic factors and it is difficult to predict ozone behaviour in the presence of specific compounds, other ingredients and environmental factors such as medium pH, temperature and humidity. Residual ozone is the concentration of ozone that can be detected in the medium after application to the target surface. Both the instability of ozone under certain conditions and the presence of ozone-consuming materials affect the level of residual ozone available in the medium. Therefore, it is important to distinguish between the concentration of applied ozone and residual ozone necessary for effective disinfection. It is advisable to monitor ozone availability during treatment (Pascual et al. 2007).Food components are reported to interfere with the bactericidal properties of ozone (Guzel-Seydim et al. 2004). Efficacy of ozone is demonstrated more readily when targeted microorganisms are suspended and treated in pure water or simple buffers (with low ozone demand) than in complex food systems, in which it is difficult to predict how ozone reacts in the presence of organic matter(Choetal.2003).Organic substances with high ozone demand in a medium may compete with microorganisms for ozone (Khadre et al. 2001). Hence, the presence of organic matter or dissolved solids in water intended for washing of fruits and vegetables may increase ozone demand and may form undesirable byproducts due to reaction with ozone. The formation of these byproducts may shorten the shelf life, change the organoleptic quality or jeopardise the safety of the final product (Khadre et al.2001).The effectiveness of ozone against microorganisms depends not only on the amount used,butal soon the residual ozone in the medium and various environmental factors such as medium pH, temperature, humidity, additives (surfactants, sugars, etc.) and the amount of organic matter surrounding the cells (Restaino et al. 1995). For example, whole-fruit bubbling of ozone in stored apples inoculated with E. coli O157:H7 was found to be more effective than dipping apples in ozone-containing water.

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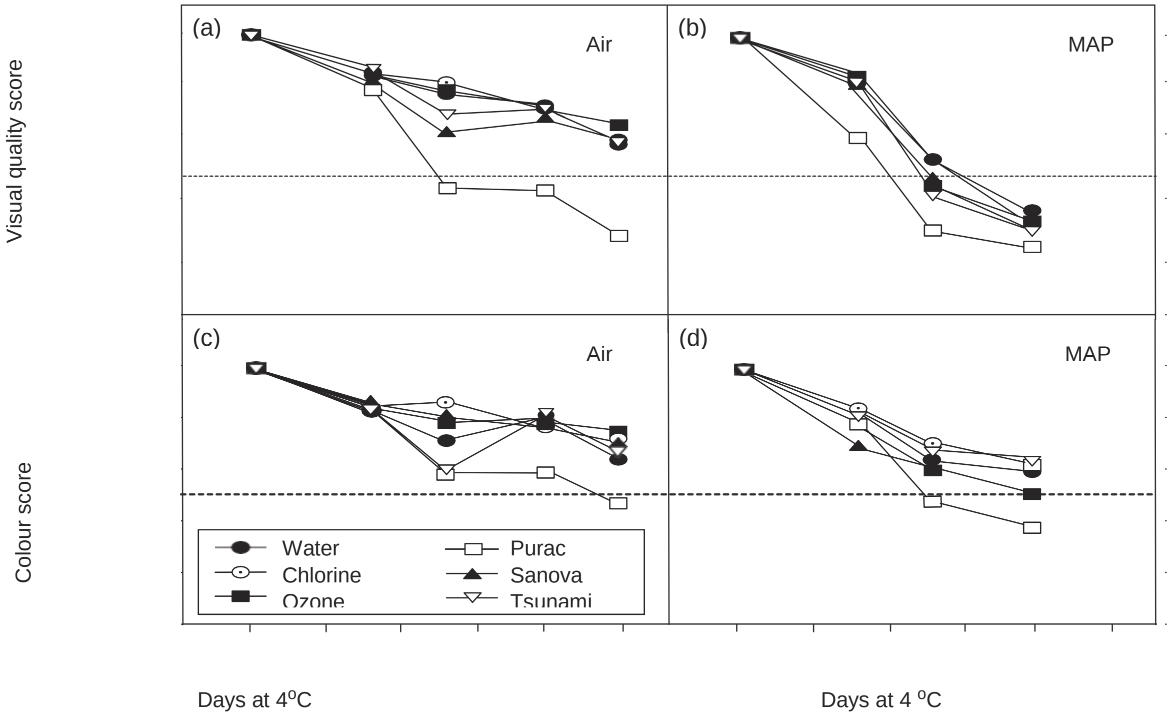
Factors influencing efficacy of ozone.

Parameters	Factors
Extrinsic factors	
Water quality	pH, temperature, turbidity, organic matter, oxidizable inorganic materials (e.g. ferrous iron, manganous, sulfide, etc.)
Ozone	Concentration, contact time
Decontaminationtreat ment	Application method (dipping, spraying and agitated,rubbed or static condition during exposure), produce/water ratio,single or multiple batches,
Intrinsic factors	
Microbialload	Characteristics of microbial strain, physiological states of the bacterial cells, natural or inoculated microorganisms, populationsize
Foodproduct	Type of fruit and vegetable, characteristics of the product surfaces(cracks,crevices,hydrophobictendencyandtexture), relation weight and surfacearea

V. CALCULATIONS & RESULTS

grams per hour × 4.41 = ppm or mg/L of ozone



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VI. CONCLUSION

The effectiveness of ozone against microorganisms present in food systems depends on several factors, including the amount of ozone applied, the residual ozone in the medium, various environmental factors such as medium pH, temperature, humidity and additives (surfactants, sugars, etc.), and the amount of organic matter surrounding the cells. To facilitate enhanced control of both quality and safety parameters of ozone-treated foods, mathematical models incorporating various independent factors governing ozone processing are required to describe biochemical reactions and microbial inactivation. Based on these modelling approaches, process optimization can be carried out and specific safety constraints can be taken into account. A detailed study of the influence of food ingredients on both the inactivation and quality degradation kinetics is required to account for the complexity of food systems. Additionally, revisiting the mechanisms of the reactions of ozone with organic materials will contribute to establishing the impact of specific radical species on target microorganisms. Overall it can be concluded that ozonation is a potential treatment for producing safe and high-quality minimally processed fruit and vegetables but that specific treatment conditions must be developed and defined for each produce prior to ozone treatment.

REFERENCES

1) Achen, M. and Yousef, A.E. (2001) Efficacy of ozone against Escherichia coliO157:H7 on apples, J Food Sci, 66(9): 1380–4.

2) Aguayo,E.,Escalona,V.H.andArtes,F.(2006)Effectofcyclicexposuretoozone gas on physicochemical, sensorial and microbial quality of whole and sliced tomatoes,PostharvestBiologyandTechnology,39:169–77.

3) kbas, M.Y. and Ozdemir, M. (2006). Effectiveness of ozone for inactivation of EscherichiacoliandBacilluscereusinpistachios,InternationalJournalofFood Science & Technology, 41:513–19.

4) Artes-Hernandez, F., Aguayo, E., Artes, F. and Tomas-Barberan, F.A. (2007) Enriched ozone atmosphere enhances bioactive phenolics in seedless table grapes after prolonged shelf life, J. Sci. Food Agric., 87: 824–31.

5) Badiani, M., Fuhrer, J., Paolacci, A.R. and Sermanni, G.G. (1995) Deriving critical levels for ozone effects on peach trees [Prunus persica (L) Batsch] growninopen-topchambersincentralItaly,8thInternationalSymposiumon Environmental Pollution and its Impact on Life in the Mediterranean Region, Rhodes, Greece: Inst Lebensmitteltechnologie AnalytischeChemie.

6) Barth, M.M., Zhou, C., Mercier, J. and Payne, F.A. (1995) Ozone storage effects onanthocyanincontentandfungalgrowthinblackberries,JFoodSci,60(6): 1286–8.

7) Beltrán, D., Selma, M.V., Tudela, J.A. and Gil, M.I. (2005b) Effect of different sanitizers on microbial and sensory quality of fresh-cut potato strips stored under modified atmosphere or vacuum packaging, Postharvest BiolTechnol, 37: 37–46.

ISSN : 2455-9679
Impact Factor : 2.015

8) Beuchat, L.R. (1992) Surface disinfection of raw produce, Dairy, Food and Environmental Sanitation, 12(1):6–9.

9) Bialka,K.L.andDemirci,A.(2007)DecontaminationofEscherichiacoliO157:H7 and Salmonella enterica on blueberries using ozone and pulsed UV-ligh, Journal of Food Science, 72(9):391–6.

10) Boyce, T.G., Pemberton, A.G., Wells, J.G. and Griffin, P.M. (1995) Screening for Escherichia coli O157-H7 a nationwide survey of clinical laboratories, J Clin Microbiol, 33(12): 3275–7.