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EFFECT OF EDIBLE COATING AND DIFFERENT PACKAGING MATERIALS ON THE QUALITY AND SHELF LIFE OF PLUM (*PRUNUS DOMESTICA* L.)

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ABSTRACT

The present investigation was aimed at assessing the Effect of edible coating and different packaging materials on the quality and shelf life of Plum. The study was conducted using a completely randomized design with three replications. Each replication included eight treatments that were coated with edible coating, which was made with 1% gum arabic and 2% glycerine and included various packaging materials such as butter paper, transparent polythene, paddy straw, tissue paper, brown paper envelope, soft cardboard box, and aluminium foil. All the coated and packed fruits were kept for 18th days to the study of effect of edible coating and packaging material on the shelf life and quality attributes of plum. it was determined the physical, biochemical parameters and sensory attributes were assessed at an interval of 2 days till 18th day. The result showed that all the treatments performed on the quality and shelf life of Plum with regard to physical, biochemical, and sensory characteristics while utilizing various packaging materials. Finally, we find that soft cardboard box, performed the best overall and extended the shelf life of the Plum. Fruit weight 65.66 g, length 41.15 mm, width 44.91 mm, both diameter 51.11 mm, and 49.39 mm and fruit decay 6.67% and biochemical i.e. pH 5.42, TSS 13.71°Brix, Ascorbic acid 7.66 mg/100gm Total titratable acidity 0.69%, Reducing sugar 4.62%, Non reducing sugar 6.01%, Total sugar 10.63% etc.

***Keywords*:** Plum, Edible coating, Storage, packaging materials.

Introduction

Among the stone fruits plum is an important fruit crop and ranks next to peaches in economic importance. Plum belongs to genus Prunus, sub-family Amygdaloidea and family Rosaceae. Order: Rosales. Plum is botanically known as *Prunus domestica*. Plums are mainly identified in two types (*Prunus domestica)* European plum and (*Prunus salicina)* Japanese plum. It is an important temperate fruit used as fresh and also in preserved form. Grown primarily in temperate climates. Of all the stone fruits grown worldwide, plums are one of the most significant. Peaches, cherries, and apricots are among the other well-known stone fruits found in plums. Plum varieties number more than 2000. only a small percentage of which are significant from a business standpoint. Plum cultivars require a long winter chilling time of 700 hours when cultivated on foothills, while in plains low chilling varieties need 250 hours. It grows well at 18-35°C and 0°C with optimal temperature of 7.2°C or below Sand loam to calm loam soils with a pH of 5.5–6.5 are ideal for growing plums, and water- logged soils produce fantastic results.

Peptides, minerals, anthocyanins, carotenoids, and phenolic acids are just a few of the many bioactive substances found in plums. Plums are an important part of our diet in terms of both nutrition and their useless as food and nutrients. Plums include vitamin C, which has the ability to be an antioxidant and shield the body from diseases like cancer, arthritis, and asthma while also boosting immunity. Studies have shown that eating plums lowers serum amino transferase and inhibits lipid peroxidation, which both slow the development of liver cancer. Chlo-genic acid in plums is a major source of antioxidant activity; 100 g of plums has an antioxidant activity ranging from 144.4 to

889.6 mg of vitamin C (Mishra, *et al.,* 2012). Plums have abundance of bioactive compounds such as phenolic acids, anthocyanins, carotenoids, minerals and pectin's. For many decades plums have been used in Indian medicine as a component of natural drugs used in case of leucorrhea, irregular menstruation and miscarriage (Kayano *et al.,* 2002). It has been demonstrated that plum extracts lower levels of allergen immunoglobulin E. Prunes contain polyphenol and flavonoid concentration, plum extract can stop the growth of many bacteria, including *Staphylococcus aureus* and *Bacillus cereus* (Karasawa, *et al.,* 2012).

A 23-thousand-acre area yielded 12,391,467 metric tons of production per year from India (FAOSTAT, 2016-2022). Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Uttar Pradesh, Punjab, and Haryana are the states in India that produce the most plums. J&K (17.24%) and Plum HP (21.28%) are the next two largest producers of plums and Uttarakhand is the first state which accounting (44.40%) of the country's total production. Plums have a short shelf-life period due to fast ripening behavior after harvesting and their perishable nature. Plums are seasonal fruit. Because quality characteristics including colour, firmness, total acidity, and total soluble solids are lost more quickly after harvest, the postharvest storage life is comparatively short. Inhibiting fruit ripening through reduced ethylene production, respiration and transpiration rates, softening, pigment changes, increased total soluble solids, and decreased total acidity is known as cold storage. Plums have 2-6 weeks commercial shelf life depending on cultivar (Abdi, 1997).

The storage life of fruit increases with the use of Arabic Gum as it reduces the rate of water loss when used as a coating material. It has been recently proposed that applying Gum Arabic on fruits revealed notable differences and increases shelf life of fruit. Because of their increased moisture content. The effectiveness of Gum Arabic increases when combine with glycerin.

Materials and Methods

Mature bright red colour plum fruits were purchased in a single lot from the local market of Gwalior and brought to Post Harvest Management Laboratory, Department of Horticulture, School of Agriculture, ITM University, Gwalior.

Pre-treatment of plum fruits: All the fruits were washed with tap water to remove dirt; dust and all the extraneous material present on the surface of the fruits. The defect free plum fruits were dipped in 200 ppm of calcium chloride solution for 2 minutes. All the fruits were wiped out with the help of tissue paper to remove the extra moisture present on the surface. All the dried fruits were divided into two parts, one part was left without coating (T_0- Control) and rest of the fruits were coated with edible coating prepared by using 1% gum arabic and 2% glycerine solution.

Packaging of plum fruits: The coated fruits were left for 15-20 minutes until the coated surface got dried and packed in different packing material viz, (T_1) butter paper, (T_2) transparent polythene, (T_3) paddy straw, (T_4) tissue paper, (T_5) brown paper envelope, (T_6) soft cardboard box, and (T_7) aluminium foil. Total five fruits were packed in each packaging material and stored for 18 days. For the assessment of impact of edible coating coupled with packaging material on.

Physical Parameters: The fruit weight (gm), Fruit width (cm) and fruit polar diameter (cm) were analysed by using weighing balance and Vernier caliper in each treatment respectively. Fruit decay (%) was calculated by the percent weight reduction with respect to initial and final weight. The weight was measured by using a laboratory level weighing scale having 0.01 g accuracy.

Biochemical Parameters: The biochemical parameters viz pH, titratable acidity (%), TSS (ºBx), Ascorbic Acid (mg/100g), total sugars, reducing sugars and non-reducing sugar were analysed by the methods suggested by Ranganna, 2012.

All the observations were recorded at 1, 3, 6, 9, 12, 15 and 18th days of the storage. Colour and odour were also recorded to find the impact of coating and packaging on the appearance.

Statistical Analysis: The results obtained during the investigation were statistically analyzed through analysis of variance at 1 per cent level of significance (Sahu and Das, 2014).

Results and Discussion

Effects of packaging material on physical observations: The study's findings highlight the effectiveness of different packaging materials on the quality of plum during storage. Treatment (T_6) (soft cardboard box), as the most successful in improving the shelf life of plums. This treatment consistently led to maintain both diameters, reduced weight loss, including length, width and significantly lower levels of decay or spoilage at 1, 3, 6, 9, 12, 15 and 18th days after storage. Followed by treatment (T_1) with minimum changes in diameters, weight losses, length, width and less decay percentages. These results indicate that soft card board box (T_6) is a for prolonging quality and increased shelf life of plum at

18th days after storage. Fruit decay percent was recorded and found that during the 6th to 9th days of storage it was non-significant records and noted with the minimum fruits damage. The fruits decay was observed in 12th day. Soft cardboard box treatment (T_6) at 6.67% (Table 1). This trend continued on the on the 18th day with also same as spoilage percentage. In contrast, the control treatment (T_0) consistently showed the highest spoilage percentages throughout the observation period.

Edible coating signifies a primary thin skin formed onto the surface of food (Basumatary *et al*., 2022). It is one of the preserving and packaging techniques all over the globe and its common application fruits and vegetables (Verma *et al.*, 2023; Omveer *et al.*, 2023; Kumar *et al.*, 2023 and Shreelakshmi *et al.*, 2023). Packaging can serve as a mass transfer barrier to control gases (CO_2 and ethylene) diffusion, moisture migration, solutes transfer (salts, additives, pigments), organic vapor transport (aromas, solvents), lipid passage between tissues of food and to or from the local environment (Devi *et al*., 2023). It protects foods from physical, mechanical, and chemical damage. It can also act as a carrier for anti-microbials, antioxidants, prebiotics, probiotics, nutraceuticals, flavours, colours, and other additive and bioactive compounds (Díaz-Montes and Castro-Mu˜ noz, 2021). Edible packaging enhances product appearance and handling characteristics. Therefore, it enhances the quality and service-life of post-harvested fresh and processed food items.

Effect of packaging material on biochemical observations: It was noted that minimum changes pH occurred in plum packed in soft cardboard box (T_6) with 3.49, followed by butter paper (T_1) with 3.54 and the (T_6) continued to show the best results on the 18th day with 5.42. whereas, (T_0) Control consistently resulted in the highest pH content throughout the observation period, and lowest performer in all the treatments. Similar trend was recorded for TSS noted that least changes occurred in plum packed in soft cardboard box (T_6) with 11.23 B^o, followed by butter paper (T_1) with 11.18 B^o and (T_6) at 3rd day of storage. Furthermore, on the 18th day of storage treatment T_6 (soft cardboard box) highest TSS i.e. 13.71 B^o whereas, (T_0) Control consistently resulted in the TSS was increased extremely throughout the observation period. Overall decreasing trend was noted for Ascorbic acid content in the plum during storage. However least change in ascorbic acid was recorded for soft cardboard box (T_6) with 9.13mg/100g followed by butter paper (T_1) with 9.13mg/100g at 3rd day of storage. The treatment T_6 had highest ascorbic acid content at 18th day of storage (7.66mg/100g).

Minimum changes for titratable acidity for the treatment soft cardboard box (T_6) with 0.79% was recorded followed by butter paper (T_1) with 0.77% and (T_6) continued to show the best results on (Table 2) the 18th day with 0.69% whereas, (T_0). Control consistently resulted in the total titratable acidity was highly decreased throughout the observation period. After the 6th day reducing sugars observations data was significant recorded. soft cardboard box (T_6) with 5%. followed by butter paper (T_1) with 4.90% and (T_6) continued to show the best results on the 18th day with 4.62%. whereas, (T_0). Control recorded to be lowest reducing sugar among all the treatments. After the 6th day non reducing sugar observations data was significant recorded. The soft cardboard box (T_6) with 4.63%. followed by butter paper (T_1) with 4.76% and (T_6) continued to show the best results on the 18th day with 6.01%. whereas, (T_0) Control recorded to be highest range of non-reducing sugar with the lots of physiological damages among all the treatments. Total sugars by the 3th day of observation is significant as per the data recorded. soft cardboard box (T_6) with 9.50%. followed by butter paper (T_1) with 9.51% and (T_6) continued to show the best results on the 18th day with 10.63% total sugar was minimum reduced in all the treatments but (T_6) was best ever. whereas, (T_0).

Respiration is a catabolic process in which oxygen is taken-in and substrate molecules (sugars, lipids, starch, and organic acids) are broken-down to release carbon dioxide, water and energy by fruits and vegetable cells (Sharma *et al*., 2024). Fresh fruits have a high tendency to perish mainly due to the presence of considerable amount of moisture (75–95 %), respiration and transpiration processes, high ethylene production, enzymatic processes like browning, off flavor and softening of tissues and attacks from microorganisms (Devi *et al*., 2023; Raghav *et al*., 2016). This problem is further elevated by mechanical injury, temperature abuse, improper maintenance of relative humidity and poor air circulation during storage and transportation. To maintain quality factors like color, texture, flavor, taste, nutritional value and microbial safety for longer durations, various preservation processes have been investigated, however, edible packaging is the most promising sustainable solution. Acidity decreases or pH increases during storage as simpler sugar is produced during ripening/maturity. Water loss may consider while important aspect for the titratable acidity and TSS as the concentration of fruits changes due to moisture loss (Basumatary *et al*., 2021).

Colour and odour of stored plum was observed as these are important for visual appearance for sensory aspect. The treatments revealed that the fruits packaged in soft cardboard box (T_6) highest scored in all sensory evaluation. Including visual appearances and colour or odour. This was followed by the fruits packaged in the butter paper (T_1) and control (T_0) received the lowest sensory scores. Peel colour changed during storage in all plum samples to dark purple as could be inferred from the decrease in the values of chroma and hue angle. This can be due to the synthesis of anthocyanins, the pigment contributing to the purple colour of plums (Valero *et al*. 2013). The colour changes in plums were delayed by all the edible coatings, suggesting a delay in the maturation/ripening of the fruits and suppression of the metabolic activities as reported earlier by Eum *et al*. (2009) and Valero *et al*. (2013).

Conclusion

It can be concluded from the results of all the treatments performed on the quality and shelf life of Plum with regard to physical, biochemical, and sensory characteristics while utilizing various packaging materials. Finally, we find that significantly superior treatment (T_6), with a soft cardboard box, performed the best overall and extended the shelf life of the plum, followed by treatments (T_1), with using butter paper, and conversely, (T_0) i.e., Control displayed the least of all.

Table 1 : Effects of packaging material on physical observations

Treatment	Fruit weight (g)							Fruit length (g)							Fruit width (mm)						
	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day
T_0	67.31	66.99	66.61	65.19	64.07	62.12	57.63	43.62	42.88	42.47	41.93	41.43	40.44	39.34	46.79	46.76	45.98	44.73	43.74	42.54	41.68
T_1	69.46	69.19	69.16	68.57	66.58	66.58	64.11	44.2	43.83	43.55	43.06	42.56	41.75	40.74	45.67	45.67	45.67	45.67	44.96	43.76	42.1
T_2	69.71	69.26	68.58	67.43	65.99	64.77	61.47	44.05	43.65	43.35	42.84	42.34	41.54	40.53	46.29	46.26	45.22	45.22	44.05	42.85	41.22
T_3	69.03	68.54	68.35	67.47	66.5	64.89	62.72	44.05	43.7	43.43	42.93	42.43	41.63	40.62	47.91	47.8	46.27	46.27	44.85	43.65	41.98
T_4	69.04	68.55	68.15	66.48	65.81	63.77	60.16	44.07	44	43.37	42.87	42.37	41.63	40.62	47.03	46.99	45.32	45.32	44.34	43.14	41.9
T_5	69.52	69.28	68.95	68.33	67.06	66.49	63.07	44.18	43.8	43.56	43.05	42.55	41.73	40.72	45.67	45.6	45.58	45.58	44.63	43.43	42.07
T_6	68.45	68.32	68.3	67.65	67.44	66.84	65.66	44.45	43.92	43.72	43.25	42.75	42.05	41.15	47.21	47.15	46.68	46.68	46.11	44.91	43.14
T_7	69.84	68.77	67.53	66.23	66.23	62.69	59.56	43.93	43.6	43.3	42.63	42.13	41.33	40.36	47.43	47.37	45.1	45.1	44.05	42.85	41.76
SE(m) ±	**0.46**	**0.45**	**0.43**	**0.41**	**0.57**	**0.6**	**0.69**	**0.13**	**0.2**	**0.13**	**0.16**	**0.16**	**0.16**	**0.16**	**0.44**	**0.45**	**0.32**	**0.3**	**0.33**	**0.33**	**0.33**
C.D. (1%)	**1.38**	**1.35**	**1.31**	**1.25**	**1.72**	**1.81**	**2.07**	**0.4**	**0.59**	**0.39**	**0.49**	**0.5**	**0.49**	**0.49**	**1.34**	**1.36**	**0.97**	**0.92**	**0.99**	**0.99**	**0.99**

	Fruit polar diameter (mm)							Fruit equatorial diameter (mm)							Fruit decay (%)				
Treatment	**0 Day**	**3 Day**	**6 Day**	**9 Day**	**12 Day**	**15 Day**	**18 Day**	**0 Day**	**3 Day**	**6 Day**	**9 Day**	**12 Day**	**15 Day**	**18 Day**	**6 Day**	**9 Day**	**12 Day**	**15 Day**	**18 Day**
T_0	54.31	53.95	53.47	52.87	51.59	49.1	46.31	52.12	51.8	51.4	49.44	49.44	46.96	44.21	13.33	40	53.33	60	53.33
T_1	55.25	54.91	54.81	54.26	53.56	51.91	49.82	53.1	52.77	52.43	51.06	51.09	49.42	47.15	0	13.33	20	26.67	20
T_2	54.44	54.1	53.76	53.22	52.36	50.9	48.48	52.19	51.87	51.51	50.14	50.14	48.45	46.03	6.67	26.67	40	40	33.33
T_3	55.3	54.97	54.62	54.06	53.2	51.72	49.36	52.94	52.62	52.29	50.9	50.9	49.31	46.99	6.67	26.67	40	40	40
T_4	55.39	55.03	54.57	54.02	53.13	51.41	48.99	52.97	52.62	52.27	50.88	50.88	49.11	46.61	6.67	20	33.33	33.33	40
T_5	55.49	55.15	54.74	54.18	53.31	51.78	49.39	53.01	52.7	52.36	50.98	50.98	49.15	46.65	0	13.33	26.67	40	26.67
T_6	55.84	55.51	55.3	54.83	54.08	53.1	51.11	53.47	53.18	52.84	51.6	51.6	50.6	48.67	0	0	6.67	6.67	6.67
T_7	54.97	54.62	54.26	53.77	52.94	51.35	49.01	52.68	52.32	51.99	50.66	50.66	49.04	46.57	6.67	33.33	46.67	53.33	46.67
SE(m) ±	**0.23**	**0.23**	**0.23**	**0.23**	**0.24**	**0.25**	**0.25**	**0.26**	**0.25**	**0.25**	**0.25**	**0.25**	**0.26**	**0.27**	**N/A**	**N/A**	**20.16**	**25.7**	**23.64**
C.D. (1%)	**0.71**	**0.7**	**0.69**	**0.69**	**0.71**	**0.76**	**0.74**	**0.77**	**0.76**	**0.75**	**0.75**	**0.75**	**0.8**	**0.83**	**5.27**	**7.82**	**6.67**	**8.5**	**7.82**

Table 2 : Effect of packaging material on biochemical observations

	Fruit pH							TSS (°Brix)							Ascorbic acid (mg/100g)						
Treatment	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day
T_0	3.53	3.66	3.85	4.12	4.65	5.18	5.74	10.4	10.79	11.9	12.5	12.9	13.41	14.05	9.16	9.14	9.09	9.03	8.91	6.84	5.84
T_1	3.41	3.54	3.7	3.93	4.45	4.99	5.54	10.88	11.18	11.64	12.24	12.64	13.17	13.81	9.14	9.13	9.1	9.06	8.94	7.86	7.06
T_2	3.48	3.63	3.79	4.04	4.57	5.11	5.66	10.73	11.03	11.88	12.48	12.88	13.39	14.03	9.17	9.14	9.09	9.04	8.94	7.75	6.58
T_3	3.42	3.58	3.75	4.01	4.55	5.1	5.66	10.76	11.06	11.68	12.28	12.68	13.19	13.83	9.15	9.12	9.08	9.04	8.95	7.77	6.6
T_4	3.49	3.64	3.79	4.05	4.6	5.14	5.7	10.75	11.05	11.81	12.41	12.81	13.36	14	9.16	9.13	9.09	9.05	8.94	7.8	6.64
T_5	3.46	3.61	3.78	4.02	4.56	5.1	5.63	10.83	11.13	11.66	12.26	12.66	13.18	13.82	9.15	9.11	9.07	9.02	8.94	7.84	6.76
T_6	3.38	3.49	3.66	3.89	4.39	4.92	5.42	10.93	11.23	11.63	12.17	12.57	13.07	13.71	9.15	9.13	9.11	9.07	8.97	7.92	7.66
T_7	3.52	3.67	3.84	4.1	4.63	5.16	5.71	10.82	11.12	11.76	12.36	12.76	13.27	13.91	9.13	9.11	9.08	9.03	8.93	7.4	6.05
SE(m) ±	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**0.03**	**0.03**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.11**	**0.15**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.11**	**0.15**
C.D. (1%)	**0.07**	**0.07**	**0.08**	**0.08**	**0.08**	**0.09**	**0.09**	**0.22**	**0.22**	**0.19**	**0.2**	**0.2**	**0.2**	**0.2**	**0.02**	**0.02**	**0.02**	**0.02**	**0.03**	**0.34**	**0.45**

Treatment	Total titratable acidity (%)							Reducing sugar (%)							Non-reducing sugar (%)							Total sugar (%)						
	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day	0 Day	3 Day	6 Day	9 Day	12 Day	15 Day	18 Day
T_0	0.81	0.8	0.75	0.73	0.67	0.6	0.54	5.14	5.1	4.68	4.57	4.49	4.41	4.23	4.21	4.51	5.05	5.81	6.34	6.49	6.61	9.35	9.61	9.73	10.37	10.83	10.9	10.84
T_1	0.79	0.77	0.75	0.73	0.72	0.69	0.63	5.14	5	4.9	4.8	4.74	4.65	4.57	4.17	4.51	4.76	5.43	5.89	6.05	6.04	9.31	9.51	9.66	10.23	10.63	10.7	10.61
T_2	0.79	0.77	0.76	0.75	0.73	0.71	0.68	5.1	5	4.71	4.65	4.57	4.49	4.41	4.26	4.58	5.08	5.64	6.19	6.31	6.27	9.35	9.58	9.79	10.29	10.75	10.79	10.68
T_3	0.76	0.75	0.73	0.72	0.71	0.69	0.68	5.24	5.2	4.77	4.71	4.62	4.51	4.41	4.09	4.36	4.98	5.59	6.14	6.3	6.33	9.33	9.56	9.75	10.3	10.77	10.81	10.74
T_4	0.73	0.72	0.71	0.69	0.69	0.65	0.63	5.1	5	4.83	4.74	4.65	4.57	4.46	4.22	4.56	4.94	5.55	6.1	6.3	6.3	9.32	9.56	9.77	10.29	10.75	10.82	10.76
T_5	0.76	0.73	0.72	0.71	0.69	0.68	0.64	5.14	5	4.83	4.77	4.68	4.59	4.51	4.25	4.55	4.84	5.48	6	6.13	6.1	9.32	9.55	9.67	10.25	10.68	10.72	10.61
T_6	0.79	0.79	0.77	0.76	0.76	0.75	0.69	5.17	5.1	5	4.9	4.8	4.74	4.62	4.16	4.4	4.63	4.95	5.8	5.94	6.01	9.33	9.5	9.63	10.19	10.6	10.68	10.63
T_7	0.76	0.73	0.72	0.71	0.69	0.67	0.64	5.14	5.1	4.83	4.74	4.57	4.49	4.38	4.2	4.46	4.94	5.6	6.23	6.4	6.5	9.35	9.56	9.77	10.34	10.8	10.88	10.88
SE(m) ±	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.112**	**0.094**	**0.051**	**0.034**	**0.034**	**0.031**	**0.025**	**0.13**	**0.1**	**0.05**	**0.12**	**0.03**	**0.03**	**0.03**	**0.02**	**0.02**	**0.03**	**0.01**	**0.01**	**0.01**	**0.01**
C.D. (1%)	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.03**	**N/A**	**N/A**	**0.155**	**0.102**	**0.104**	**0.095**	**0.075**	**N/A**	**N/A**	**0.16**	**0.37**	**0.1**	**0.09**	**0.09**	**N/A**	**0.06**	**0.1**	**0.04**	**0.04**	**0.04**	**0.04**

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