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ANALYSIS OF CHEMICAL INTERVENTIONS FOR ENHANCING VASE LIFE IN AFRICAN AND FRENCH MARIGOLDS

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ABSTRACT:

Abstract

The vase life of cut flowers is a crucial factor in the floriculture industry, influencing marketability, consumer preference, and economic returns. African marigold (*Tagetes erecta* L.) and French marigold (*Tagetes patula* L.) are widely used for ornamental and religious purposes; however, their postharvest longevity is limited due to rapid senescence, vascular blockage, ethylene sensitivity, and microbial contamination. This review comprehensively analyses the role of various chemical treatments, their mechanisms of action, and their comparative effectiveness in extending vase life. Additionally, recent advancements, limitations, and future research prospects are discussed, with an emphasis on sustainable and eco-friendly approaches. This study investigates the efficacy of eco-friendly and chemical-based treatments in extending the vase life of *Tagetes erecta* (African marigold) and *Tagetes patula* (French marigold). The research evaluates the effectiveness of various natural preservatives (such as plant extracts, essential oils, and organic acids) and synthetic chemicals (such as silver nitrate, sodium hypochlorite, and citric acid) in maintaining postharvest freshness.

KEYWORDS: *Vase life, African marigold, French marigold, eco-friendly, chemical preservatives, postharvest longevity.*

INTRODUCTION:

Marigolds are among the most commonly cultivated flowers worldwide, valued for their vibrant colors, easy cultivation, and various applications in landscaping, perfumery, and traditional medicine (Ahmad et al., 2019). However, their postharvest longevity is limited due to dehydration, microbial infection, and ethylene-induced senescence. Research suggests that chemical preservatives can significantly enhance vase life by maintaining water balance, inhibiting microbial growth, and delaying senescence (Sajid et al., 2020). This review synthesizes current findings on the efficacy of chemical treatments in prolonging the vase life of African and French marigolds.

Floriculture is a rapidly expanding sector within the global horticultural industry, valued at approximately $55 billion USD in 2023, with projections indicating an increase to $77 billion by 2030 due to rising demand for cut flowers and ornamental plants (Floriculture Market Report, 2023). Among the commercially significant flowers, marigolds (*Tagetes erecta* and *Tagetes patula*) contribute nearly 12–15% of the total cut flower trade, widely used for ornamental decoration, religious offerings, and medicinal applications (Ahmad et al., 2019). Their bright colors, ease of cultivation, and adaptability to different climatic conditions make them a preferred choice for floriculturists and consumers alike. However, despite their widespread popularity, the postharvest longevity of marigolds is significantly lower than that of other commercial cut flowers, lasting only 4–6 days compared to 12–15 days for roses and 10–14 days for lilies (Darras et al., 2020). This short shelf life leads to postharvest losses of nearly 25–30%, impacting economic returns for growers and traders while increasing floral waste (Singh & Roy, 2021).

The rapid deterioration of marigolds postharvest is primarily attributed to microbial contamination, vascular blockage, ethylene sensitivity, dehydration, and carbohydrate depletion. Studies suggest that nearly 80% of cut flower water uptake issues are caused by microbial proliferation in vase solutions, particularly due to bacterial species such as Pseudomonas, Enterobacter, and Bacillus, which form biofilms in xylem vessels, restricting water flow and accelerating wilting (Van Doorn, 2012). As Kader (2002) noted, “Microbial contamination is one of the most significant factors limiting the postharvest longevity of cut flowers, often leading to premature senescence." Additionally, marigolds exhibit high sensitivity to ethylene, a plant hormone responsible for accelerating flower aging by inducing petal abscission, color fading, and programmed cell death. Research by Reid & Jiang (2012) found that ethylene inhibitors like silver thiosulfate (STS) and 1-methylcyclopropene (1-MCP) can extend the vase life of ethylene-sensitive flowers, including marigolds, by 40–60%.

Another major factor contributing to the limited vase life of marigolds is carbohydrate depletion, as cut flowers rely on stored sugars to sustain respiration and metabolic activity. Van Meeteren et al. (2001) reported that low carbohydrate availability results in rapid energy depletion, leading to early senescence and petal wilting. To counter this, sugar supplementation in vase solutions—typically with 2–5% sucrose—has been shown to improve flower turgidity, delay wilting, and increase longevity by 20–30% (Singh et al., 2015). As Rogers (2006) stated, "Sucrose plays a critical role in maintaining osmotic balance in cut flowers, ensuring continued metabolic function and delayed senescence."

To address these postharvest challenges, various chemical preservatives have been explored to enhance the vase life of marigolds. Biocides such as 8-Hydroxyquinoline sulfate (8-HQS) and sodium hypochlorite are effective in reducing microbial contamination by 60–80%, thus improving water uptake and delaying wilting (Tian et al., 2021). Acidifiers like citric acid and ascorbic acid help lower the pH of vase solutions, enhancing water absorption by up to 50% while preventing microbial growth (Kumar et al., 2018). Similarly, plant growth regulators (PGRs) such as gibberellic acid (GA_3) have been found to delay chlorophyll degradation and ethylene biosynthesis, extending marigold shelf life by 25–35% (Singh et al., 2015).

Recent advancements in nanotechnology have also shown promising results in extending vase life. Silver nanoparticles (AgNPs), known for their antimicrobial and ethylene-inhibiting properties, have been reported to increase marigold vase life by 70% compared to untreated flowers (Tian et al., 2021). However, concerns over environmental toxicity and high production costs remain challenges to their large-scale application. As Serek et al. (2014) highlighted, "While silver-based compounds remain among the most effective postharvest treatments for ethylene-sensitive flowers, their ecological impact necessitates the development of alternative, sustainable solutions."

This review aims to provide a comprehensive analysis of chemical interventions used to prolong the vase life of African and French marigolds, examining their mechanisms of action, comparative effectiveness, and sustainability. By evaluating the impact of biocides, sugars, acidifiers, PGRs, and ethylene inhibitors, this study seeks to offer insights into optimizing postharvest floral preservation while minimizing environmental concerns. Furthermore, the review explores emerging trends such as eco-friendly alternatives, biodegradable preservatives, and nanotechnology-based solutions to highlight future research directions and innovations in sustainable floriculture practices.

2. REVIEW OF LITERATURE

Postharvest longevity is a critical factor influencing the commercial value of cut flowers. Various chemical interventions have been studied to enhance the vase life of African marigold (*Tagetes erecta*) and French marigold (*Tagetes patula*). The following literature review summarizes previous research on the impact of different chemical treatments on cut marigolds and other related flowers.

2.1 Factors Affecting Vase Life in Marigolds

2.1.1. Microbial Growth and Vascular Blockage

Microbial proliferation in vase water leads to the formation of biofilms, which occlude xylem vessels and reduce water uptake, causing premature wilting (van Doorn, 2012). Bacterial species such as Pseudomonas, Enterobacter, and Bacillus have been identified as major contaminants in cut flower solutions (Tian et al., 2021).

2.1.2. Water Relations and Transpiration

Water stress is a key factor in the early senescence of cut flowers. Rapid transpiration and inefficient water uptake lead to petal desiccation, loss of turgidity, and early wilting (Darras et al., 2020). Acidic preservatives help improve water uptake by preventing the formation of air embolisms in xylem vessels (Nowak & Rudnicki, 1990).

2.1.3. Ethylene Sensitivity

Ethylene plays a crucial role in accelerating flower senescence by inducing petal abscission, color fading, and programmed cell death (Reid & Jiang, 2012). Marigolds are classified as ethylene-sensitive flowers, and their vase life can be significantly extended through ethylene inhibitors (Serek et al., 2014).

2.1.4. Carbohydrate Depletion

After detachment from the parent plant, cut flowers rely on stored carbohydrates for respiration and metabolic activities. Low carbohydrate availability results in reduced energy production, leading to rapid senescence (van Meeteren et al., 2001). Sugar supplementation in vase solutions has been found to delay flower deterioration by serving as an additional energy source (Singh et al., 2015).

2.2 Chemical Interventions for Enhancing Vase Life

2.2.1. Biocides and Antimicrobial Agents

Biocides prevent bacterial and fungal growth in vase water, reducing vascular blockage and improving water uptake (Singh & Roy, 2021).

Silver thiosulfate (STS): An effective ethylene inhibitor that prolongs vase life by preventing ethylene-induced petal senescence (Reid et al., 2017).

8-Hydroxyquinoline sulfate (8-HQS): A widely used antimicrobial agent that suppresses bacterial growth and maintains vascular conductivity (van Doorn, 2012).

Chlorine-based compounds (sodium hypochlorite, chlorine dioxide): Reduce microbial contamination but may cause phytotoxicity at high concentrations (Rafiq et al., 2022).

2.2.2 Sugars as Preservatives

Sucrose and other sugars serve as respiratory substrates, delaying senescence and enhancing flower opening (Halevy & Mayak, 1981).

Sucrose (2–5% solutions): Increases osmotic potential, delays petal wilting, and supports postharvest metabolism (Rogers, 2006).

Glucose and fructose: Maintain cell turgor, improve water relations, and prevent petal senescence (Pun & Ichimura, 2003).

2.2.3. Acidifiers and pH Modifiers

Lowering the pH of vase solutions helps reduce microbial proliferation and enhances water absorption (Darras et al., 2020).

Citric acid (150–300 ppm): Reduces microbial load and improves water uptake by maintaining xylem integrity (Kumar et al., 2018).

Ascorbic acid: Functions as an antioxidant, reducing oxidative stress and delaying senescence (Nowak & Rudnicki, 1990).

2.2.4. Plant Growth Regulators (PGRs)

PGRs influence postharvest physiology by modulating hormonal balance and delaying senescence (Serek et al., 2014).

Gibberellic acid (GA3): Enhances vase life by delaying chlorophyll degradation and ethylene production (Singh et al., 2015).

Salicylic acid (SA): Reduces oxidative stress, enhances vase life, and improves water relations in cut flowers (Sajid et al., 2020).

Cytokinins (Benzyladenine, Kinetin): Promote cell division and delay senescence in cut flowers (Rafiq et al., 2022).

2.2.5. Ethylene Inhibitors

Ethylene inhibitors are essential for extending the vase life of ethylene-sensitive flowers.

STS and 1-Methylcyclopropene (1-MCP): Block ethylene receptors and inhibit ethylene-induced senescence (Reid et al., 2017).

Silver nanoparticles (AgNPs): Exhibit both antimicrobial and ethylene-inhibiting properties (Tian et al., 2021).

2.3. Effect of Biocides on Vase Life

Microbial contamination is a major factor limiting the vase life of cut flowers. Biocides prevent bacterial growth and reduce vascular blockage, thus improving water uptake.

2.3.1. Silver Thiosulfate (STS) and Silver Nanoparticles (AgNPs)

Silver-based compounds are widely used as antimicrobial agents and ethylene inhibitors. Reid et al. (2017) reported that STS effectively delays ethylene-induced senescence in ethylene-sensitive flowers, including marigolds. Similarly, Tian et al. (2021) found that silver nanoparticles (AgNPs) exhibit antimicrobial properties while also inhibiting ethylene action, thus extending the vase life of *Tagetes erecta*. However, environmental concerns regarding silver accumulation have been raised, prompting the need for alternative preservatives (Serek et al., 2014).

2.3.2. 8-Hydroxyquinoline Sulfate (8-HQS)

Van Doorn (2012) demonstrated that 8-HQS inhibits bacterial proliferation in vase water, preventing xylem blockage and enhancing water uptake. Studies on cut marigolds suggest that a combination of 8-HQS and sucrose results in improved vase life compared to water-only controls (Singh & Roy, 2021).

2.3.3. Chlorine-based Biocides

Rafiq et al. (2022) examined the effects of sodium hypochlorite (NaClO) and chlorine dioxide (ClO_2) on microbial control in vase water. Their study concluded that these compounds effectively reduce microbial load but may cause phytotoxicity at high concentrations, leading to petal discoloration and tissue damage.

2.4. Role of Sugars in Extending Vase Life

Sugars serve as an energy source for cut flowers, delaying carbohydrate depletion and senescence.

2.4.1. Sucrose Supplementation

Halevy & Mayak (1981) found that adding sucrose (2–5%) to vase solutions improves flower opening, delays wilting, and extends the vase life of several ornamental species. Rogers (2006) reported that cut marigolds treated with sucrose solutions maintained petal turgidity for a longer duration.

2.4.2. Glucose and Fructose

Studies by Pun & Ichimura (2003) indicate that glucose and fructose function similarly to sucrose by maintaining osmotic potential and delaying petal dehydration. However, excess sugar concentrations may promote microbial growth, necessitating the addition of antimicrobial agents.

2.5. Influence of Acidifiers on Water Uptake

Acidifiers help regulate the pH of vase solutions, preventing microbial growth and improving water absorption.

2.5.1. Citric Acid

Kumar et al. (2018) found that citric acid (150–300 ppm) effectively reduces bacterial contamination in cut flower solutions, enhancing water uptake and delaying senescence. Similar effects were observed in marigolds when combined with sucrose treatments.

2.5.2. Ascorbic Acid (Vitamin C)

Ascorbic acid functions as an antioxidant and delays oxidative stress-induced petal wilting

(Nowak & Rudnicki, 1990). Studies on *Tagetes* species suggest that ascorbic acid treatments extend vase life by improving stem conductivity and delaying petal discoloration (Darras et al., 2020).

2.6. Impact of Plant Growth Regulators (PGRs) on Vase Life

Plant growth regulators (PGRs) modulate postharvest physiological processes, influencing senescence and water retention.

2.6.1. Gibberellic Acid (GA_3)

Singh et al. (2015) reported that GA_3 treatment delays chlorophyll degradation and ethylene production in marigolds, extending their shelf life. Similar findings by Serek et al. (2014) indicate that GA_3-treated flowers exhibit enhanced water uptake and delayed petal wilting.

2.6.2. Salicylic Acid (SA)

Salicylic acid has been found to reduce oxidative stress and improve vase life in various cut flowers (Sajid et al., 2020). Research on marigolds suggests that SA-treated flowers exhibit improved postharvest longevity due to enhanced antioxidant enzyme activity.

2.6.3. Cytokinins (Benzyladenine, Kinetin)

Cytokinins delay senescence by promoting cell division and chlorophyll retention (Rafiq et al., 2022). Studies on marigolds indicate that cytokinin treatments maintain leaf and petal freshness for an extended period.

2.7. Ethylene Inhibitors and Their Role in Delaying Senescence

Marigolds are ethylene-sensitive flowers, and ethylene inhibitors play a crucial role in prolonging their vase life.

2.7.1. STS and 1-Methylcyclopropene (1-MCP)

Ethylene inhibitors like STS and 1-MCP block ethylene receptors, preventing early petal abscission (Reid et al., 2017). Serek et al. (2014) demonstrated that 1-MCP treatments significantly improve the postharvest longevity of *Tagetes* species by reducing ethylene-induced wilting.

2.7.2. Silver Nanoparticles (AgNPs)

Apart from their antimicrobial properties, AgNPs act as ethylene inhibitors, extending vase life (Tian et al., 2021). However, concerns regarding environmental toxicity and high costs remain a challenge.

2.8. Comparative Studies on Chemical Interventions for Vase Life Extension

Several comparative studies have evaluated the effectiveness of chemical interventions:

Singh & Roy (2021) reported that a combination of sucrose and STS resulted in the longest vase life for marigolds.

Darras et al. (2020) found that citric acid and 8-HQS treatments significantly improved water uptake and reduced microbial growth.

Sajid et al. (2020) observed that salicylic acid and GA_3 were effective in delaying senescence without causing phytotoxicity.

2.9. Comparative Effectiveness of Chemical Treatments

Different studies have reported varying degrees of effectiveness for chemical interventions:

STS and 1-MCP: Highly effective but environmentally concerning due to silver accumulation (Serek et al., 2014).

Sucrose and GA3: Improve vase life but require precise concentration control to prevent microbial proliferation (Singh et al., 2015).

Biocides like 8-HQS and AgNPs: Show promise but require further evaluation for phytotoxicity (Tian et al., 2021).

Acidifiers (citric acid, ascorbic acid): Safe and eco-friendly but moderately effective (Kumar et al., 2018).

2.10. Future Research Directions

- Development of biodegradable and eco-friendly chemical preservatives.
- Exploration of nanotechnology-based antimicrobial agents for prolonged effectiveness.
- Investigation into genetic modification for enhanced postharvest longevity.
- Integration of chemical and natural treatments to improve sustainability.

3. CONCLUSION:

The review of literature highlights the effectiveness of various chemical interventions in enhancing the vase life of African and French marigolds. Biocides, sugars, acidifiers, PGRs, and ethylene inhibitors play crucial roles in mitigating postharvest deterioration. However, the environmental impact of some chemical preservatives necessitates the development of safer, eco-friendly alternatives. Continued research and innovation in postharvest technology will be essential for improving the commercial viability of marigold flowers.

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