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REVIEW PAPER

Economic Sustainability of Composting Municipal Solid Waste: A Review

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Abstract

The increase in population, especially in countries with weaker economic development, leads to an increase in the amount of solid municipal waste, especially organic components. The increase in solid municipal waste requires more and more space for its disposal. Composting could be one of the most environmentally and economically acceptable methods of disposing of solid municipal waste, which would produce a product (compost) suitable for use in agricultural production. The economic sustainability of composting depends on investment costs, labor costs, system organization, market value of compost and local business conditions. The analyzed literature shows significant differences in the economic success of different composting systems. Decentralized systems achieved a return on investment within 10 years, while some centralized windrow systems had a return on investment period of 55 years. Composting plants require significant initial investments and operating costs, which is why the economic sustainability of the process is an important factor in their application. The research was conducted by reviewing the relevant scientific literature and applying the thematic analysis approach to 53 scientific publications. The results show that investment costs, labor costs, system organization and the possibility of placing compost on the market are key factors in economic sustainability. Bioreactor systems achieved the highest compost sales prices and shorter payback periods compared to windrow systems. The results indicate that the economic viability of composting does not depend solely on the technology used, but on a combination of financial, organizational and market factors that determine the long-term profitability of the system. The aim of the paper was to demonstrate the economic viability of composting municipal solid waste by reviewing the relevant scientific literature.

Keywords: economic sustainability, solid municipal waste, composting

Introduction

The increasing growth of the world population is one of the factors that affect the principles of sustainable development. According to Bradshaw et al. (2026), who refer to the United Nations (2024) estimate, the world population in 2026 reached approximately 8.30 billion people. It is precisely the increase in the world population that has resulted in the generation of enormous amounts of municipal solid waste (Sabki et al., 2018). Municipal solid waste is defined as waste generated by human activities and discarded by society (Ferronato and Torretta, 2019). Municipal solid waste management is becoming a challenging task in urban areas of the world, especially in rapidly growing cities (Hoornweg and Bhada-Tata, 2012). Management encompasses all activities from generation to final disposal, and it includes the control, production, storage, collection, transfer and transportation, treatment, and disposal of municipal solid waste in accordance with the best practices of public health, economics and finance, engineering, administration, legal, and environmental considerations (Johari et al., 2014). Improper collection and treatment of municipal solid waste represents a significant problem for public health and environmental quality and causes global warming, since organic waste is one of the main sources of methane emissions from landfills (Duan et al., 2021). Also, improper management of municipal solid waste can cause degradation of land resources, a threat to human and animal health, and long-term negative impacts on the environment (Ferronato and Torretta, 2019). In order to prevent negative impacts, a sustainable municipal solid waste management strategy is needed (Vyas et al., 2022). Organic components of municipal solid waste represent one of the biggest problems due to the large quantities that are continuously produced over time and due to biochemical and physical characteristics that require proper handling in accordance with biological processes (Policastro and Cesaro, 2022). The latest report by the European Environment Agency states that around 60 million tons of biowaste are produced annually in the European Union member states, or 130 kg per capita. The largest percentage, 55-60%, is food waste, while green waste accounts for 30-35% (Eurostat, 2025).

Composting can be one of the good strategies for managing the organic components of municipal solid waste in overcoming the above problems. Composting is the process of biological decomposition of organic waste into a product with added value and a high content of humic substances that can be used in agriculture to improve soil quality, reduce erosion, and stimulate the growth of cultivated plant species. (Nemet et al., 2021). The composting process involves simpler technology and lower costs for the disposal of municipal solid waste compared to anaerobic digestion, incineration, and pyrolysis (Murphy and Power, 2006). Mature compost can be used as an organic fertilizer and soil improver because it does not contain heavy metals and pathogenic microorganisms (Bernal et al., 2009). Composting is a more environmentally friendly way of disposing of municipal solid waste compared to landfills or incineration and is beneficial for agricultural land and pollutes the environment less (Saer et al., 2013). Composting of municipal solid waste can significantly reduce landfilling and reduce the consumption of energy required for other forms of disposal (Cadena et al., 2009). Composting is significantly cheaper than waste incineration and pyrolysis. The profitability of composting depends on the quality of the compost, the scale of the process, the selling price, and the costs of waste separation and collection (Renkow and Rubin, 1998). Composting of biodegradable waste offers significant economic prospects on several levels (Ansar et al., 2025). First, composting can lead to cost savings for municipalities due to reduced landfill needs and costs related to waste collection and disposal (Korica and Gotvajn, 2025). In agricultural production, compost is used as a substitute for chemical fertilizers, potentially reducing input costs for farmers and increasing the profitability of production (Adugna, 2016). Expanding the composting process to municipal waste creates the possibility of creating new jobs in collection, processing, and distribution, as well as stimulating the local economy and creating “green” jobs (Ansar et al., 2025).

The aim of this scientific paper was to demonstrate the economic viability of composting municipal solid waste by reviewing relevant scientific literature.

Material and Methods

The methodology of this scientific work was designed to provide a clear scientific overview of the economic viability of composting municipal solid waste through a comprehensive review of the relevant scientific literature. Scientific literature was systematically retrieved from key databases such as Web of Science, BASE, OpenAIRE, CAB International, HRČAK, Google Scholar, and so forth. These databases were used due to the wide availability of data related to the economic viability of the composting process of municipal solid waste as well as the composting process itself. The search for relevant scientific literature was conducted using a combination of keywords and phrases. Keywords included ”economic viability of composting,”, ”solid municipal waste, ”composting revenues and costs,” and ”composting process.” The keywords were used individually or in various combinations to increase the likelihood of finding relevant scientific literature. This search method enabled the filtering of the vast amount of available literature to find the scientific literature most relevant to the research topic. Each selected piece of scientific literature underwent a relevance check to confirm its direct applicability to this review. The selected texts for analysis were thoroughly studied and elaborated upon to fit the concept of the paper. The selection process was based on previously defined inclusion criteria with a focus on relevance to methods of economic viability of composting municipal solid waste. The inclusion criteria included scientific papers related to the economic viability of composting municipal solid waste that contained relevant data on investment costs, operating costs, revenues, and economic indicators. The exclusion criteria referred to papers that did not address the economic viability of composting, were not available in full text, or did not contain data relevant to the subject of the research. The review included papers published in the period from 1998 to 2026. Their selection was made by reviewing the titles, abstracts, and full texts. Data analysis consisted of coding scientific texts to identify recurring themes and factors discussed in the selected scientific literature. A total of 53 scientific publications were included in the analysis. The coding process followed a thematic analysis approach where scientific texts were categorized based on dominant themes emerging from the data. A consistent approach in analyzing and synthesizing scientific sources-maintained uniformity throughout the review writing process.

Results and Discussion

Basic Composting Process

In the ancient history of pre-Columbian Indians and ancient Egyptians, composting was used as a primitive technique for improving soil (Sayara et al., 2020). In the last 40 years, composting techniques have developed significantly, and the positive effects of compost have been confirmed by numerous scientific studies (Bernal et al., 2009). Composting is the controlled aerobic microbiological decomposition of organic matter, which produces nutrient-rich compost (Narayana, 2009). For a proper composting process, the most important thing is the raw material, which must have the appropriate structure, degradability, moisture and aeration (Mohammad et al., 2021). Controlling the composting process requires monitoring humidity, temperature and aeration throughout the process until the maturation or stabilization phase (Bernal et al., 2009). The composting process consists of four basic phases: mesophilic, thermophilic, cooling phase and compost maturation phase (Nemet et al., 2021). As a rule, the stages of composting take place sequentially, and the duration of each stage depends on the initial composition of the mixture, water content, aeration and microbiological composition (De Bertoldi et al., 1983). During the mesophilic phase of the composting process, temperatures of 15 to 40°C develop where bacteria, fungi and actinomycetes break down carbon-rich substances. Decomposition releases heat, which heats up the compost mixture and promotes a rise in temperature that leads to the thermophilic phase. In the thermophilic phase, the temperature rises above 40°C, which favors thermophilic bacteria that break down proteins, fats, cellulose and hemicellulose (Sole-Mauri et al., 2007). Temperatures above 50°C are crucial for the destruction of pathogenic microorganisms and weed seed germination (Liu et al., 2020). The cooling phase occurs after the thermophilic phase and its duration depends on the initial composition of the compost mixtures, and it involves a slow and long-term decomposition of lignin and other resistant components (Huang et al., 2010). In the final maturation phase, the number of microorganisms decreases and lasts from several days to several months, ending when a mature and stable compost with a lower C/N ratio and a slightly alkaline pH reaction is obtained (Abd El Kader et al., 2007; Bernal et al., 2009). The high proportion of organic components in municipal solid waste shows that composting is the best option for its disposal (Sokač et al., 2020). There are two effective methods of aerobic composting of municipal solid waste, namely pre-fermentation and post-fermentation. In pre-fermentation composting, municipal solid waste is used directly in the composting process without any prior treatment, while in post-fermentation composting, municipal solid waste is composted after separating materials that cannot be composted (Kumar, 2011). The active composting phase of organic municipal solid waste under aerobic conditions lasts an average of 2 to 4 weeks, followed by a maturation or stabilization phase of the same duration (Cesaro et al., 2019). At the very end of the process, the resulting compost is screened to remove unwanted components and prepared for further use (Marche et al., 2003). Unlike aerobic composting, the anaerobic method of composting municipal waste requires the waste to be deposited in excavated pits, where decomposition occurs in the absence of oxygen for 4 to 6 weeks. Since this method of composting requires larger areas and time, it is not suitable for urban centers (Talyan et al., 2008).

Solid Municipal Waste

According to the Intergovernmental Panel on Climate Change, municipal solid waste refers to waste collected by cities, municipalities or other forms of local government. It includes food waste, garden and park waste, paper, cardboard, wood, textiles, rubber, plastic, metal, glass, etc. (Zhu, et al., 2021). Municipal solid waste (MSW) excludes construction and demolition waste, and industrial and liquid waste from municipal sewage networks (Ross and Law, 2023). Key factors that influence the composition of urban municipal solid waste are the level of economic growth, geographical location, culture, and climate. As urbanization progresses and the population grows, the consumption of inorganic materials increases, while the share of organic materials decreases (Zambrano-Monserrate, 2021). Low- and middle-income countries tend to have a higher percentage of organic matter in their MSW (Sabki et al., 2018). The high organic matter content in MSW leads to high moisture content and reduced calorific value. This makes thermal treatment of such MSW a less favorable option compared to biological treatment such as composting (Yadav and Samadder, 2018). The composition and characteristics of the organic matter of MSW destined for composting affect the presence of undesirable substances and pathogens in the compost (Rodrigues et al., 2020). Non-degradable materials that may enter the composting process together with the organic components of MSW must be removed mechanically or during the compost refinement phase to avoid negative impacts on the soil. Non-degradable materials such as glass, plastic and other synthetic materials have a high tendency to become embedded in deeper arable soil layers, where they can block soil pores and potentially reduce water seepage and gas exchange (Cattle et al., 2020). The presence of non-degradable materials in municipal solid waste can be very effectively controlled by separating organic waste for composting (Montejo et al., 2010). The proportion of non-degradable materials in cities with poor separate waste collection systems is up to 50% of waste suitable for composting. On the other hand, in cities with good separate waste collection systems, this percentage is between 10 and 20% (Alvarez et al., 2008). Separate waste collection can improve the quality of organic waste suitable for composting, but errors during sorting and collection are still possible (Montejo et al., 2010). Mechanical separation of non-degradable components effectively reduces the presence of plastic components (microplastics), but this process also causes losses of biodegradable material through screening (Hu et al., 2024).

Composting Costs

Assessing the economic viability of municipal waste composting is crucial. Conducting a cost analysis allows for an assessment of the financial viability of introducing and maintaining a municipal solid waste composting facility, as well as potential revenue sources and long-term environmental and social benefits (Pandyaswargo and Premakumara 2014).

The costs of building a composting facility are of key importance in the very economic viability of composting solid municipal waste (Ghinea and Gavrilescu, 2016). Initial costs refer to the investment costs needed to start a business and they are one-time. In contrast, operation and maintenance costs arise periodically, in a clear time frame, usually once a year (Martín-Pascual et al., 2020). Composting solid municipal waste has the potential to reduce costs in the long term, however, it requires initial investments—that is, investment in location, infrastructure, and equipment (Kaza et al., 2016). Land for the construction of composting facilities must be readily available, and developing local communities should opt for low-tech rather than high-tech, mechanized facilities that incur significant costs. In many cases, facilities that opted for high-tech mechanized facilities co-financed by EU grants have been closed after a certain period due to high costs of infrastructure repairs and other technical requirements that exceeded their financial capacity (Pandyaswargo and Premakumara, 2014). The process of selecting a land location for a new landfill takes place over a longer period and involves significant time and energy costs (Renkow and Rubin, 1998), and small-scale composting facilities are more financially accessible and sustainable (Kaza et al., 2016). Small-scale composting refers to composting a maximum of 5 t/day, medium-scale from 5 to 100 t/day and large-scale over 100 t/day of processed organic waste. Medium- and small-scale facilities have a greater possibility of financial sustainability compared to large-scale ones because they have better process control and lower investment. Large systems require high initial investments, but with a properly designed system and the support of governments and institutions, they can achieve economic sustainability (Pandyaswargo and Premakumara, 2014).

The financial management of the project is a key factor in the success of a sustainable municipal solid waste composting process (Kaza et al., 2016). The operating costs of a facility are related to the operation and maintenance of the facility and must be financially self-sufficient (Vigneswaran et al., 2016). Operating costs include labor costs, utilities, transportation, business development, marketing, and equipment repairs and upgrades (Martín-Pascual et al., 2020). The main costs of composting are the procurement of raw materials (collection and transportation), operation and maintenance, and transportation of the finished product (Kaza et al., 2016). The level of operating costs largely depends on the municipal solid waste composting technology (Al-Rumaihi et al., 2020)—namely, simpler composting systems require less investment in equipment and lower labor costs (Aye and Widjaya 2006).

Economic Feasibility

Key factors for the success of a municipal solid waste composting project lie in the financial management of the project and the political environment of the local community (Kaza et al., 2016). The final compost produced can take many forms, but the design must meet the requirements of individual customer groups (Eggerth et al., 2007). Compost intended for gardeners is more expensive, but such compost must be of a finer structure with a high nutrient content. On the other hand, compost intended for crop production may have a lower nutrient content, but the amount produced must be sufficient for their needs in order to improve soil quality (Kaza et al. 2016). Potential buyers of compost produced from municipal solid waste are mostly conventional farmers who manage the land in the long term and deplete nutrients from it (Vigoroso et al., 2021). Also, potential buyers are organic farmers who need a nutritional alternative to artificial fertilizers (Kaza et al. 2016). The use of compost in the preparation of plant growing media can replace the use of artificial materials and increase the customer base (Boldrin et al., 2009). The profitability of the system depends on the existence of an organized market for compost, and for composting of municipal solid waste to be economically viable, the costs of disposal would have to increase significantly, and the revenue from the sale of compost would have to increase enough to cover the costs of composting (Renkow and Rubin, 1998). Research conducted in Mumbai refers to the comparison of waste disposal and a system that includes composting. Waste disposal had the lowest costs since it only included the costs of land acquisition and transportation of municipal solid waste, and the economic benefit of composting is more pronounced in densely populated areas—that is, in urban areas where land and disposal costs are high (Mehta et al., 2018). The success of compost sales depends on the marketing and quality of the produced compost that is available on the market, and quality compost can generate higher revenues and achieve higher profits (Lim et al., 2016). Today, in the market, especially in developing countries, there is a diverse offer of compost available without proper labeling of nutrients, and such a lack of products leads to unfavorable competition of compost on the fertilizer market (Danso et al., 2017). The sustainability of the municipal solid waste composting process is affected by the costs of investment, plant operation, waste transportation, quality assurance, the compost market and the continuous supply and demand chain of raw materials and products (Lim et al., 2016). The involvement of the government, private sector, policy makers, and the public are essential to support the separation of waste and its repurposing through the composting process (Danso et al., 2017). Cost data from Rowan County, North Carolina showed total MSW composting costs of $53.00/t while landfill costs were lower at $30.08/t (Renkow and Rubin, 1998).

Decentralized composting aims to develop a new waste management framework, build a closed system for the valorization of organic waste (OW), and integrate decentralized household, community, and commercial composting systems. The research covered commercial composting, community composting, and home composting. The results showed that the best option is commercial composting, with the highest benefit-cost ratio (B/C index) of 0.0067. Regarding community composting compared to home composting, the results show that the B/C index for home composting is 0.0019, higher than the index for community composting of 0.0014. Therefore, home composting is preferable to community composting (Daskal et al., 2022). When interpreting the results, it is important to note that the B/C index values are very small due to the way it is calculated. This indicator is therefore used to compare different composting scenarios, with higher values indicating a more favorable benefit-cost ratio. Although commercial composting achieves the highest B/C index, the differences between the analyzed scenarios are relatively small, indicating that the success of decentralized composting depends on local implementation conditions and system organization.

Table 1 shows several different studies on municipal solid waste composting.

Reference	System organization	Composting technology	System description	Economic indicator
Oviedo et al., 2025	Decentralized	Windrow	Composting in open compost piles, with mechanical mixing (truck, mixer, loader)	Return on investment within 10 years
Oviedo et al., 2025	Decentralized	Windrow	Mixing the compost pile is done manually using basic tools.	Increased number of working hours, which translates into higher operating costs.
Pandyaswargo and Premakumara 2014.	Local system	Windrow	Composting in open compost piles, with mechanical mixing	Selling price of compost: 70 USD/t. Return on investment within 6 years
Pandyaswargo and Premakumara 2014.	Local system	Closed bioreactor system	A closed bioreactor system in which organic waste is decomposed under controlled conditions of temperature, humidity, and aeration.	Selling price of compost: 180 USD/t. Return on investment within 7 years
Chen 2016.	Centralized	Windrow	Processing of organic waste in open compost piles, by mechanical mixing	Selling price of compost: 94 USD/t. Return on investment over 55 years

Decentralized composting represents a viable technoeconomic alternative to centralized industrial systems for the management of 100% of the organic components of municipal solid waste in rural municipalities. Table 1 presents data from a study conducted in Catalonia, Spain. The composting plant capacity is 90 t/year. The table shows a mechanized decentralized system that has proven to be the most efficient approach. The fixed costs of this system are 18,157.00 euros and the variable costs are 15,141.00 euros per year. The return on investment is achieved within 10 years from the start-up of the plant. Manual decentralized composting requires significant physical effort, which implies a greater number of working hours. Mixing in manual operation takes 732 hours per year, and in mechanized operation 43 hours per year, which translates into higher operating costs (Oviedo et al. 2025). The above results show that labor costs can have a significant impact on the economic viability of decentralized systems. In conditions of higher labor costs, mechanized systems may be more economically advantageous despite higher initial investments. Table 1 also analyzes the windrow composting system and the closed bioreactor composting system. In the smaller windrow system (input capacity 0.6t/d; output capacity: 0.1t/d), the selling price of compost was 70 USD/t, and the return on investment was 6 years. The larger windrow system (input capacity 50t/d; compost output/capacity: 27t/d) had a selling price of compost of 94 USD/t, and a return on investment of 55 years. Such a payback period indicates a very limited economic return on investment and suggests that the system, despite a positive financial result, is not economically viable without additional incentives or other sources of income. A comparison of Pandyaswargo and Premakumara 2014 and Chen 2016 indicates that the economic viability of composting systems does not depend solely on technology or sales price, since, using the same technology (windrow), the systems achieved significantly different payback periods, which indicates the importance of investment costs, system organization and local market conditions in determining economic success. Although these systems operated with a positive financial result, long payback periods indicate limited economic profitability. The results show that achieving a profit does not necessarily mean economic sustainability in the long term. The bioreactor composting system had the highest selling price of 180 USD/t, and a return on investment of 7 years (Pandyaswargo and Premakumara, 2014; Chen, 2016). Compared to windrow systems, the bioreactor system achieved a higher selling price of compost and a significantly shorter payback period. The above results indicate the possibility of achieving higher revenues from the sale of compost, although such systems require higher initial investments and more complex technical equipment. The above confirms that investment costs, labor costs and system organization play an equally important role as the composting technology itself. A comparison of decentralized, centralized and bioreactor systems indicates that the economic viability of composting depends not only on the technology applied but also on the organization of the system itself, labor costs, market value, investment investments, and local business conditions. Decentralized systems can achieve lower logistics costs and encourage greater involvement of the local community; centralized systems are burdened with high investment costs and longer payback periods. Bioreactor systems show the potential to achieve a higher market value of compost and more successful economic indicators. This shows that the economic success of the system does not depend solely on the amount of investment, but also on the ability to market products at a higher market price, although such systems require more complex technology and higher initial investments.

Conclusions

The process of composting organic components of municipal solid waste reduces the accumulation of waste in landfills, greenhouse gas emissions, and negative environmental impacts. Composting enables the conversion of organic components of municipal solid waste into compost that can be used in agriculture, horticulture, and for soil restoration. The economic viability of composting organic components of municipal solid waste depends on the capacity of the plant, the operating costs of the plant, the organization of the waste collection and transportation system, the quality of the compost produced, market demand, and support from the local government. Initial capital and operating costs are high, and savings are achieved through reduced waste disposal costs, the selection of appropriate composting technology, a quality product that generates income, and the positive impact on the environment and social benefits themselves. A review of the analyzed research has shown significant differences in economic indicators between composting systems. Some systems achieve a return on investment within a few years, while others show extremely long payback periods, indicating reduced profitability of the investment. Therefore, composting of municipal solid waste can be considered economically viable only under certain conditions, such as efficient system organization, a satisfactory mechanization system, controlled operating costs, and a secured market. Otherwise, the system may achieve unfavorable economic results. With good organization of the composting system, long-term economic profitability of waste management results, which depends not only on the system technology but also on the participation of the municipal system and the population in waste separation. Increasing the population's awareness of proper waste separation results in a reduction of biowaste pollution and the production of higher-quality compost, which results in better economic sustainability of the system. Analyzed research shows that the economic sustainability of composting is determined by the interaction of technological, organizational, and market factors, which is why the result cannot be simply generalized to all composting systems. Composting of municipal solid waste represents an environmentally acceptable and long-term sustainable solution for managing the organic component of municipal solid waste, but its economic sustainability requires high-quality system organization, development of the compost market, continuous support from local governments, and greater recognition of composting as a key part of sustainable waste management.

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Ekonomska održivost kompostiranja krutog komunalnog otpada: pregledni rad

Sažetak

Porastom broja stanovnika, nar očito u zemljama slabijeg ekonomskog razvoja, dolazi do povećanja količine krutog komunalnog otpada, posebice organskih komponenti. Povećanje količine krutog komunalnog otpada zahtijeva sve više prostora za njegovo odlaganje. Upravo bi kompostiranje moglo biti jedan od ekološki i ekonomski najprihvatljivijih postupaka zbrinjavanja krutog komunalnog otpada u kojemu bi nastao proizvod (kompost) pogodan za korištenje u poljoprivrednoj proizvodnji. Ekonomska održivost kompostiranja ovisi o investicijskim troškovima, troškovima rada, organizaciji sustava, tržišnoj vrijednosti komposta i lokalnim uvjetima poslovanja. Analizirana literatura pokazuje značajne razlike u ekonomskoj uspješnosti različitih sustava kompostiranja. Decentralizirani sustavi ostvarili su povrat ulaganja unutar 10 godina, dok su pojedini centralizirani windrow sustavi imali razdoblje povrata ulaganja od 55 godina. Postrojenja za kompostiranje zahtijevaju značajna početna ulaganja i operativne troškove, zbog čega je ekonomska održivost procesa važan čimbenik njihove primjene. Istraživanje je provedeno pregledom relevantne znanstvene literature i primjenom pristupa tematske analize na 53 znanstvene publikacije. Rezultati pokazuju da su investicijski troškovi, troškovi rada, organizacija sustava i mogućnost plasmana komposta na tržište ključni čimbenici ekonomske održivosti. Bioreaktorski sustavi ostvarili su najveće prodajne cijene komposta i kraća razdoblja povrata ulaganja u usporedbi s windrow sustavima. Rezultati ukazuju da ekonomska održivost kompostiranja ne ovisi isključivo o primijenjenoj tehnologiji, već o kombinaciji financijskih, organizacijskih i tržišnih čimbenika koji određuju dugoročnu isplativost sustava. Cilj rada bio je prikazati ekonomsku održivost kompostiranja krutog komunalnog otpada pregledom relevantne znanstvene literature.

Ključne riječi: ekonomska održivost, kruti komunalni otpad, kompostiranje