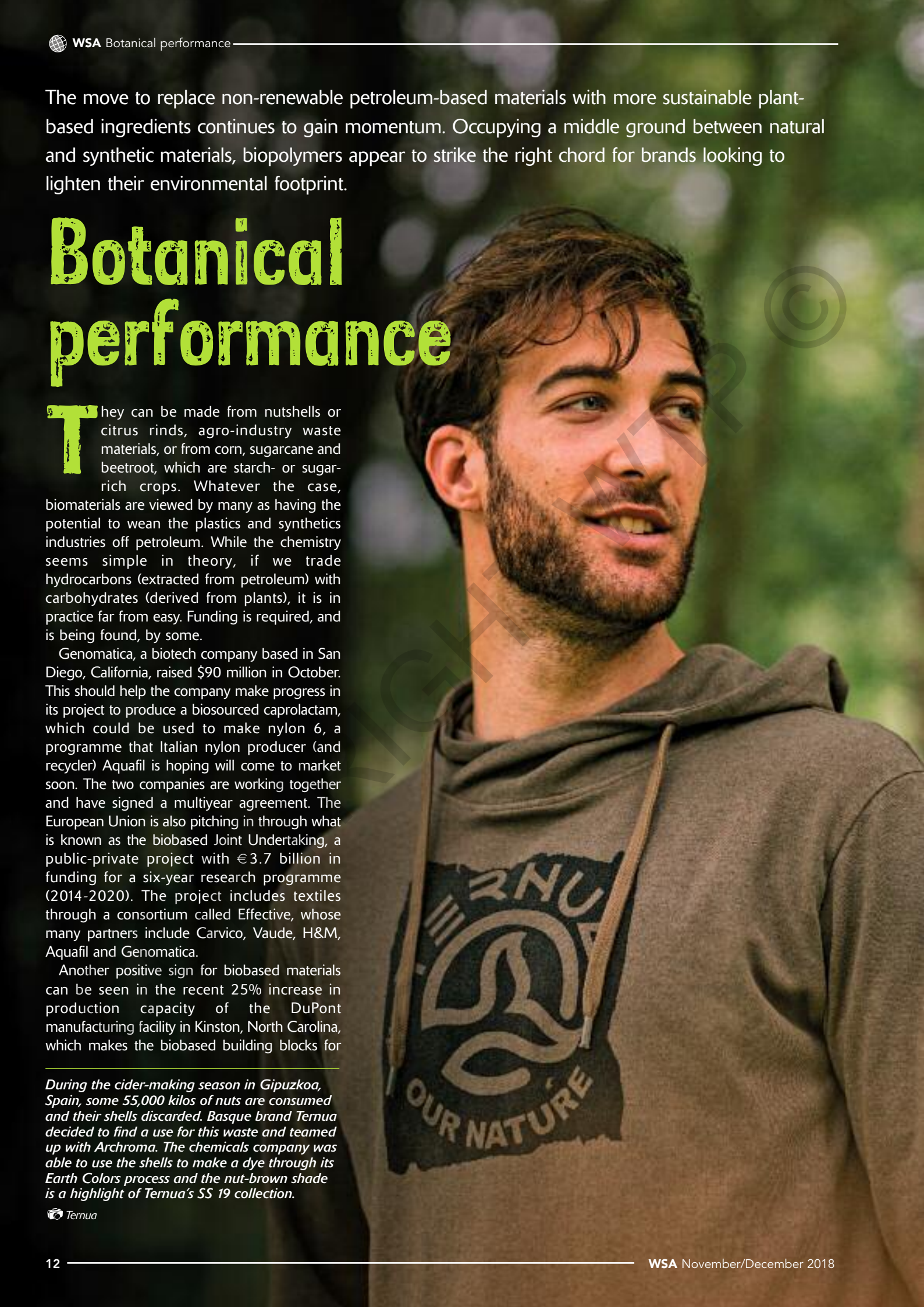
The move to replace non-renewable petroleum-based materials with more sustainable plant-based ingredients continues to gain momentum. Occupying a middle ground between natural and synthetic materials, biopolymers appear to strike the right chord for brands looking to lighten their environmental footprint.

Botanical performance

They can be made from nutshells or citrus rinds, agro-industry waste materials, or from corn, sugarcane and beetroot, which are starch- or sugar-rich crops. Whatever the case, biomaterials are viewed by many as having the potential to wean the plastics and synthetics industries off petroleum. While the chemistry seems simple in theory, if we trade hydrocarbons (extracted from petroleum) with carbohydrates (derived from plants), it is in practice far from easy. Funding is required, and is being found, by some.

Genomatica, a biotech company based in San Diego, California, raised $90 million in October. This should help the company make progress in its project to produce a biosourced caprolactam, which could be used to make nylon 6, a programme that Italian nylon producer (and recycler) Aquafil is hoping will come to market soon. The two companies are working together and have signed a multiyear agreement. The European Union is also pitching in through what is known as the biobased Joint Undertaking, a public-private project with €3.7 billion in funding for a six-year research programme (2014-2020). The project includes textiles through a consortium called Effective, whose many partners include Carvico, Vaude, H&M, Aquafil and Genomatica.

Another positive sign for biobased materials can be seen in the recent 25% increase in production capacity of the DuPont manufacturing facility in Kinston, North Carolina, which makes the biobased building blocks for



During the cider-making season in Gipuzkoa, Spain, some 55,000 kilos of nuts are consumed and their shells discarded. Basque brand Ternua decided to find a use for this waste and teamed up with Archroma. The chemicals company was able to use the shells to make a dye through its Earth Colors process and the nut-brown shade is a highlight of Ternua's SS 19 collection.

Ternua

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Sorona, by DuPont Industrial Biosciences, is now bluesign certified. The biosynthetic polyester (a PTT) is being used in blends with natural fibres such as cotton, merino wool, linen and Tencel. The yarn's natural stretch makes it a possible alternative to spandex for comfort stretch applications.
Sorona

Sorona and Susterra. Renee Henze, marketing director for DuPont Industrial Biosciences, says demand for Sorona is up. "Sorona's features meet today's market needs," she says, citing its soft hand feel and natural elasticity that make it particularly suitable for athleisure. Sorona can even replace spandex in comfort stretch applications, she insists. Sorona is a PTT fibre, categorised as a polyester, but it is only partially plant-based, 37% of its make-up is bioPDO (the result of a fermentation process by 'engineered' or genetically-modified bacteria) while 63% is derived from conventional petrochemical terephthalic acid (PTA). DuPont is working on developing a fully biobased polyester, but this is still some way down the road; when it does come to market, it will be more expensive than conventional polyester, says Ms Henze.

Virent, a company based in Madison, Wisconsin, is working to develop a process to produce the chemical raw materials for a fully biosourced polyester. A demonstration plant, constructed in 2009, is in operation and can produce biobased paraxylene and biofuels. Paraxylene is a precursor to the terephthalic acid that is used to make polyester and PET. Virent is currently working on scaling up the process to provide what would be the first commercially available bio-PTA, but challenges remain. Ralph Lerner, head of business development, will not even indicate a timeline.

The company has developed a catalytic process that converts sugars and carbohydrates from plants and biomass into renewable chemicals and fuels. This method is said to be more flexible than biological, or fermentation, processes. It says its patented 'bioforming' process can convert conventional feedstocks, such as beet sugar, sugar cane and corn starch. What it is calling "next generation cellulosic feedstocks", which would include bagasse (the residue left after the extraction of juice from sugar cane), corn stover, grasses, sorghum and even wood, are also potential raw materials for this. Industrial processes require high-quality feedstock that is available in large quantities, a situation that only traditional crops (such as corn, cane and beets) provide today. While biomass-based sugars are of interest longer term, these still require additional technical development to get to commercial scale. Raw material from biomass may be cheaper, Mr Lerner states that it is important to consider other costs involved in working with biomass, including logistics, processing and removing impurities.

Founded in 2002, Virent was acquired by Tesoro, a fuels refining company, in 2016. It recently became a wholly-owned subsidiary of petrochemical group Marathon Petroleum, but still operates under the Virent name.

Polyamide made from castor-bean oil is one of the few fully plant-based synthetics available on the market. Italian fibre producer Fulgar has offered a biobased nylon 10.10, known as Evo, since 2015. The specialty nylon has been quite successful for Fulgar and it now produces 100 tonnes annually, despite a higher price-tag. "From a comfort and performance point of view, Evo yarns have many interesting properties compared to conventional polyamide 6.6," says Alan Garosi, Fulgar's marketing director. The specific weight of polyamide 10.10 is lower than that of nylon 6.6. Mr Garosi says this means that a lighter weight fabric will have a higher covering power. But its main draw is moisture management, which is closer to that of a polyester than a polyamide. "Moisture uptake for Evo is 1.6% compared with 4% for

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conventional nylon," he says.

Ricinus communis, also known as castor bean or castor oil plant is not a food crop and it grows in arid regions, so it does not raise any land management issues with regards to competing with food production. Fulgar is currently looking to identify where the plant is sourced to be able to communicate a transparent supply chain to its customers with regard to its biopolymer.

Biomass versus bio-waste

Orange Fiber, an Italian start-up seeking to transform the cellulose of orange peels into yarns, has drawn much media attention, having partnered with Italian couturier Salvatore Ferragamo in 2017 and with Swedish fast fashion brand H&M this year. "In this way, we demonstrate that Orange Fiber can have applications in the upscale market and the mass market," Enrica Arena, company co-founder, tells *WSA*. Though it has learned much from these first experiences, the young company is going back to the drawing board. Having developed an acetate yarn from the cellulose-rich citrus peels, Orange Fiber would now like to turn the agro-industry waste into a viscose fibre, which may have a larger market appeal. It has also changed its raw material sourcing



Italian eco-tech designer Tiziano Guardini has adopted two of Fulgar's yarns, the castor-oil biosourced nylon Evo and post-industrial mechanically recycled polyamide 6.6 Q-Nova, for his collections. Shown here, a style presented at Milan Fashion Week for SS 19.

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partner and is now working with a different orange juice maker in Sicily. These new developments require funding and the young company is now looking to raise €500,000 to move forward with all of its projects.

Agro-industry processing residues are also finding new markets in dyestuffs, in a programme launched by chemicals company Archroma to make its Earth Colors dyes. In a partnership with Basque outdoor brand Ternua, the range has recently been expanded to include dyes made from the shells of walnuts. Visits to cider orchards are popular there as locations for large family lunches or dinners, which usually consist of cider, grilled meat and, for dessert, local walnuts served with cheese and quince jelly. This generates a high volume of walnut shells that have, until now, gone to waste. Ternua's director of innovation, Edu Uribesalgo describes the genesis of the project that is putting the shells to better use: "We talked with the Natural Cider Association of Gipuzkoa and they agreed to collaborate. We found a company in Tudela where the shells could be ground up and we got in touch with Archroma to see whether they could handle the chemical process of transforming the shells into natural dye." The result is a range of products dyed nut-



At the 2018 Global Change Award ceremony, Taiwanese actress, model and sustainability influencer Chiling Lin wore a gown made from Orange Fiber, winner of a Global Change Award in 2016. The young company is currently looking for new funding to develop a viscose yarn in addition to the initial acetate it makes from citrus waste.

Orange Fiber

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brown – what else? –offered in the brand's spring-summer 2019 collection. "Natural resources produce natural colours and these match outdoor market trends," says Mr Uribesalgo. Ternua claims it has already collected 300 kilogrammes of walnut shells, which it says can be used to dye up to 10,000 garments.

More brands are signing up for Archroma's Earth Colors, the chemical company's marketing director, Nuria Estape, has told *WSA*, which she says is due to its combination of "performance and nature" and because it can be considered a circular economy system. These dyes are currently used on cellulose or cotton fibre fabrics, but Archroma is working on developing versions that could be suitable for use on synthetic fabrics.

Botanical ingredients

An even more ambitious plan is under way at Portuguese knitter Tintex to develop dyestuffs from natural botanical ingredients, but with the same performance properties, including reproducibility, as synthetic dyes. The programme, known as Picasso, is a partnership with Portuguese research centres CeNTI and CITEVE, biotech company Bioinvitro and Ervital, a supplier of organic ingredients. The plan is to develop 25 to 30 colours derived from plants or mushrooms, for a commercial launch in early 2019. In addition to the usual browns, Tintex has successfully developed yellow shades, which were on view at Première Vision this September. Among the many challenges in developing these alternative dyes, Pedro Magalhães, head of innovation at Tintex, singles out fastness to light, a common issue he says with natural extracts, which is why the consortium has focused its research on ingredients that have a naturally high resistance to UV light. The other issue is vibrancy, which is more difficult to obtain from natural extracts, though the latest developments show some promising results, according to Mr Magalhães. Tintex plans to present the first commercial products on wool and cotton fabrics.

Growing interest in plant-based synthetics has led the Textile Exchange to launch a website dedicated to biosynthetic technologies and materials. "Biosynthetics have the potential to play an important role, not only in the transition to a fossil-free future but also to combat climate change," says Liesl Truscott, the organisation's director for Europe and for materials strategy. "There is however the need to ensure that the renewable raw materials are produced in a sustainable way." Most companies insist that the biosourced ingredients they use come from non-food and non-GMO crops. Many biosynthetic chemicals, as we have seen, are extracted from starch or sugar crops but little to no information is given to prove that these resources do not find their way into the food chain. Corn, for instance, would not be considered non-food unless processing residues are used, the Textile Exchange says. The organisation points out that castor beans is a major crop for biosynthetics and can be considered non-food and non-GMO. When the biotech ingredients are extracted from agricultural waste, as is the case for Archroma's Earth Colors dyes or Orange Fiber, or from biomass, though this has yet to be made commercially feasible, the issue of competition with food crops is not relevant and a positive use is found for a growing resource.



Non-fluorinated DWR finish Teflon EcoElite is 60% biobased. The finish is said to have the same properties as a conventional DWR with regards to water repellency, but it is not oleophobic. Chemours is working on increasing the stain-release functions of its biotech finish.

Chemours

Biotech DWRs

While suppliers of water repellent finishes phase out fluorocarbon chemistry, they are also shifting to plant-based formulations. This is the case for Organotex, developed by Swedish company Organoclick, Neoseed a treatment developed by Japanese company Nicco and Ecorepel Bio, the DWR developed by Swiss company Schoeller Technologies; all claim to be made from renewable natural resources. Teflon, arguably the most well-known water repellent finish, is also available in a biosourced EcoElite version. Marketed by Chemours, spun-off from DuPont in 2015, this non-fluorinated DWR contains 60% biosourced materials, which do not come from food-sources nor are genetically modified, the company insists. Teflon EcoElite, whose chemical name is Zelan R3, matches the water repellency levels of traditional PFC finishes but, like many non-fluorocarbon DWRs, is not oil-repellent. Chemours has recently introduced another version, Zelan R2, which is only 30% biobased and can therefore be offered at a lower price point. The long-standing partnership with Huntsman Textile Effects, a US-based chemicals company that has been selling Teflon for the past 30 years, has recently officially been extended.

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